ASSESSING THE CUMULATIVE EFFECTS OF LINEAR RECREATION ROUTES ON WILDLIFE HABITATS ON THE OKANOGAN AND WENATCHEE NATIONAL FORESTS.

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Abstract

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We conducted a literature review to document the effects of linear recreation routes (roads, motorized trails, non-motorized trails, designated and groomed ski and snowmobile routes) on wildlife and to complete an assessment of the current level of human influences on focal wildlife species habitats on a portion of the Okanogan and Wenatchee National Forests. The assessment consisted of seven steps: 1) Identification of wildlife species and groups, 2) Identification of focal species within each wildlife group, 3) Identification of the road and trail associated factors for each focal species, 4) Development of assessment processes and GIS models to evaluate the influence of road and trail associated factors on focal species habitats, 5) Application of the models to assess the current conditions of focal species habitats, 6) Identification of information gaps, and 7) Monitoring and adaptive management. Completion of this process yields a platform for the consistent evaluation of the cumulative effects of roads and recreation trails on wildlife habitats relative to the existing baseline conditions.

We identified 193 articles concerning the effects of recreation trails and roads on wildlife. Of these, 176 articles were used to identify the interactions between roads, recreation trails and 27 focal wildlife species. These articles included technical publications, books, agency publications, theses, and dissertations.

The science available to describe the interactions between focal wildlife species and roads is more developed than available for recreation trails. Much of the research has been focused on wide-ranging carnivores and ungulates. Other lesser known species could benefit from additional research on the effects of roads and this is especially true for less mobile species where roads may inhibit movements or fragment habitats. The most commonly reported interactions included displacement/avoidance where animals were reported as altering their use of habitats in response to roads or road networks. Disturbance at a specific site was also commonly reported and included disruption of animal nesting, breeding or wintering areas. Collisions between animals and vehicles were commonly reported and affected a wide diversity of wildlife species, from large mammals to amphibians. Finally, negative edge effects associated with roads or road networks constructed within habitats, especially late-successional forests were commonly identified.

Fewer wildlife species have been studied relative to the interactions with motorized trails. Ungulates and some wide-ranging carnivore species were the best studied, and many wildlife could benefit from further research designed to identify these interactions. The most common interaction identified in the literature includes displacement/avoidance where animals altered their use of habitats in response to motorized trails or trail networks. Disturbance at a specific site was also identified and, as with roads, was usually associated with wildlife breeding or young-rearing.

The most common interactions reported in the literature that we reviewed between non-motorized trails and focal wildlife species were displacement/avoidance which altered habitat use, and disturbance at a specific site during a critical time period. The interaction of the focal species and motorized or non-motorized trails were quite similar. Depending on the wildlife species, some were more sensitive to motorized trail use, while others were more sensitive to non-motorized trail use. Based on our current level of understanding, both forms of recreation have effects on wildlife. Motorized trails had a somewhat greater magnitude of effects, such as longer distances in which wildlife were displaced, for a greater number of the focal species we reviewed. Additional research would be useful to further refine the interactions of specific species with motorized and non-motorized trails.

The interactions between snowmobile routes and focal wildlife species are poorly documented for many species. These interactions need to be further refined with additional research and monitoring. The most common interactions that we documented from the literature included trapping as facilitated by winter

human access, displacement/avoidance, and disturbance at a specific site, usually wintering areas. An additional interaction that occurred for winter recreation routes was the effect that snow compaction has on the subnivean sites used by small mammals. Small mammals can either be suffocated as a result of the compaction or their subnivean movements can be altered due to impenetrable compact snow. Snow compaction associated with snowmobiling was also identified as altering the competitor/predator communities because the packed snow routes provide winter access to areas not normally available to some species.

We only documented a few interactions between ski trails and focal wildlife species due to the limited literature available on the subject. Ungulates were the most thoroughly studied group and very few others had been investigated. The most common interactions that we found in the literature included trapping as facilitated by winter route access, displacement avoidance, and disturbance at a specific site (wintering areas in this case). As with snowmobile routes, ski trails also included the interactions of snow compaction and competitor/predator community alterations.

We developed 16 simple GIS models to estimate the current level of influence of linear recreation routes on focal wildlife species habitats. Four of the models addressed winter recreation, 11 non-winter, and on included the winter and spring periods. These models were applied to a case study area on a portion of the Okanogan and Wenatchee National Forests to illustrate their use and interpretation. The application of the cumulative effects models showed that, in general, non-winter activities had a higher level of cumulative effects than groomed and designated winter route activities. Habitats in which cumulative effects were ranked as having a high level of human influence in many assessment areas included core areas for grizzly bears, late-successional habitats, riparian habitats, and wetlands. The effectiveness of these habitats could be restored using some of the approaches described below.

Over the course of this review we kept track of information gaps that hindered our understanding of wildlife, road and recreation trail interactions. The following suggested areas of study could be accomplished through the use of an adaptive management approach and well designed monitoring and research: (1) The interactions between wildlife, non-motorized trails, snowmobile routes, and ski trails need to be better defined for many wildlife species, especially those with small home ranges and limited mobility. (2) The interactions between wildlife and the intensity of human use on recreation trails (such as trail density or number of hikers/unit time) needs to be better described. (3) The interactions between wildlife habitat use and the spatial extent (such as the proportion of a home range or watershed) of recreational activity are an area that is very poorly understood. (4) Finally, we need to be able to relate recreation trail and wildlife interactions to the demography of a particular species of management interest. Adaptive management and monitoring designed to lead to greater understanding of any of these areas would greatly facilitate our management goals of conserving ecosystem processes and functions while providing recreation opportunities.

The information provided in this review, and subsequent development and application of cumulative effects models, improve the knowledge base that can be used to evaluate project proposals and make informed decisions. The findings of our review collaborate with the findings of other reviews. In addition, this information can be used to develop and apply mitigation tools to address the kinds of interactions that have been described for each focal wildlife species or group. Tools that have been used to mitigate recreational activities are described in general terms below: (1) Spatial separation of humans and wildlife in key habitats. This could be used to address situations where displacement/avoidance interactions have been identified for a wildlife species of management interest. (2) Temporal separation of humans and wildlife at critical time periods. This tool could be applied where the interaction of displacement at a specific site has been identified for a wildlife species of management interest. (3) Human behaviors that reduce the effects of recreation on wildlife can be taught through information and education programs. (4) If wildlife habitat issues are identified upfront in the early stages of projects, they can be addressed proactively through project design. Hopefully, the information provided in this assessment will help accomplish this.

In order to proactively address wildlife conservation and recreation opportunities, we need to begin addressing these issues through our landscape scale planning processes. In this manner important habitats for wildlife and recreational opportunities for humans can be identified. This process could be accomplished using the following approach: (1) assess the existing level of influence that recreational activities have on wildlife habitats, (2) set compatible wildlife habitat goals and recreation goals, (3) gain further knowledge about wildlife and recreation interactions through an adaptive management approach, and (4) adapt habitat and recreation goals based on new information. In this manner, we can address the mutual goals of conserving wildlife species while providing recreation opportunities. These goals have many commonalities, not the least of which is the desire of people to experience “wildlife” during their recreational outings.

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The Assessment Process

Introduction

Increasing demand for recreational opportunities and facilities (Burchfield et al. 2000, USFS 2000b), has resulted in controversy about the potential effects of these activities on wildlife (Flather and Cordell 1995). On National Forest lands, management is focused on providing recreational opportunities compatible with ecosystem processes and functions (USFS 2000b). Understanding how recreational activities influence ecosystem processes and functions is necessary to evaluate different management options and to make informed decisions.

As demands for recreation increase, cumulative effects result from what may be individually a minor effect yet collectively significant effects over space and time. Cumulative effects can be defined as the combined effect upon a species or its habitat caused by the activity or program at hand, as well as other reasonably foreseeable events that are likely to have similar effects on the species or habitat (Weaver et al. 1987). Cumulative effects analysis assesses the effects on a system of spatial and temporal perturbations resulting from human activities (Beanlands et al. 1986). Cumulative effects analysis explicitly deals with effects and whether those effects exceed or fall short of thresholds compatible with the population or habitat goals for a given species or groups of species. Hence, cumulative effects analysis and its subsequent models are tools to perform proactive conservation for wildlife species and habitats (Weaver et al. 1987).

Although a considerable and growing body of research is available concerning recreation and wildlife interactions, sizeable gaps in our knowledge remain. Gathering reliable knowledge can be time consuming and costly because of the difficulty in controlling a wide array of variables that influence how wildlife react to human activities. Because of this, the investigation of wildlife and recreation interactions is well suited to an adaptive management approach (Gutzwiller 1993, Knight and Gutzwiller 1995).

Recreation on national forest lands includes a wide variety of activities with a correspondingly wide range of effects on wildlife. Because of this, it was necessary to narrow the scope of recreational activities considered in this assessment. Therefore, this assessment is focused on linear recreational routes; including motorized and non-motorized trails, winter ski-trails, snowmobile routes, and forest roads. These activities account for the majority of recreational activities and potential effects to wildlife habitats that occur on the Okanogan and Wenatchee national forests. It would be desirable and valuable for future efforts to be focused on providing a summary of the available science about other types of recreational activities and wildlife interactions. These other recreation activities include helicopter skiing, rock-climbing, snow-play areas, and several others, but were beyond the scope and funding of this effort.

This assessment has been designed with three primary objectives in mind: 1) Review the relevant literature about roads, recreation trails, and wildlife interactions, 2) Develop assessment processes and geographic information system (GIS) models for the consistent evaluation of the cumulative effects of these activities on wildlife; and 3) Use the processes and models to complete a case study assessment of the effects of existing roads and recreation trails on wildlife habitats for the Okanogan and Wenatchee national forest lands located between Interstate 90 and Lake Chelan.

Methods

The assessment process consists of seven steps: 1) Identification of wildlife species and groups, 2) Identification of focal species within each wildlife group, 3) Identification of the road and trail associated factors for each focal species, 4) Development of assessment processes and GIS models to evaluate the influence of road and trail associated factors on focal species habitats, 5) Application of the models to assess the current conditions of focal species habitats, 6) Identification of information gaps, and 7) Monitoring and adaptive management. Completion of this process yields a platform for the consistent evaluation of the cumulative effects of roads and recreation trails on wildlife habitats relative to the existing baseline conditions.

Step 1. Wildlife species and groups-We used existing information about the distribution of wildlife species on the Okanogan and Wenatchee national forests to develop a list of wildlife species and to develop groups of species based upon their biology (e.g. wide-ranging carnivores, late-successional species, riparian associated species, etc.) and interactions with road and recreation trail associated factors. These information sources included watershed assessments, Late-successional Reserve Assessments (USFS 1997), and information from the Washington GAP Analysis (Dvornich et al. 1997, Johnson and Cassidy 1997, Smith et al. 1997).

A total of 395 species were included in this assessment (appendix). These included nine amphibian species, 11 reptile species, 286 bird species, 84 mammal species, and five mollusks. These species were placed into six groups (some species occurred in more than one group) that included: wide-ranging carnivores (9 species), ungulates (6 species), late-successional forest habitat associated species (71 species), riparian associated species (144 species), waterfowl and colonial nesting birds (97 species), and primary cavity excavators (11 species).

Step 2. Identification of focal wildlife species-A number of systems have been used by ecologists to evaluate or rank potential emphasis species (Kuhnke and Watkins 1999, Lambeck 1997, Lehmkuhl et al. 2001, Millsap et al. 1990). One approach that has been proposed is the "focal species" concept (Lambeck 1997) in which a suite of species that are most sensitive to a particular activity (habitat fragmentation, disturbance from a motorized trail, etc.) are used to define the acceptable levels of the activity for a group of species (such as wide ranging carnivores). Recently the focal species approach has been empirically tested for wide-ranging carnivores (Carroll et al. 2001) and birds (Watson et al. 2001) with favorable results. Therefore we used this concept to select focal wildlife species that represented groups of wildlife species.

Focal species, as described in the federal planning regulations (CFR Vol. 65 No. 218, November 2000), are species selected for use as surrogate measures in the assessment of ecological integrity. Their distribution and abundance over time provide insights into the integrity of the larger ecological system to which they belong. We selected species that represent the range of environments within the assessment area, and that serve an umbrella function, or play key roles in maintaining community structure or processes. Therefore, we selected focal species 1) whose habitat associations represented the range of habitats associated with the wildlife group, 2) whose recreation trail and road associated factors were representative of the range of the group, 3) whose populations and/or habitats could be monitored, 4) for which viability concerns were known such as federally listed or U.S. Forest Service Sensitive species, and 5) that were relatively well studied relative to the effects of road and trails on their habitat use.

Step 3. Identification of road and trail associated factors-Liddle (1997) provided a three tier disturbance classification scheme for the effects recreational activities have on wildlife. Disturbance Type 1 occurs when an animal sees, hears, smells, or otherwise perceives the presence of a human but no contact is made and it may or may not alter its behavior. Disturbance Type 2 is when habitat is changed in some way by pathway creation, camping, the presence of food or clearing of vegetation. Disturbance Type 3 involves human actions in which there is a direct and damaging contact with the animal such as hunting, fishing, collisions with vehicles and other accidental contact in which the results are similar to hunting. Alternatively, Knight and Cole (1995) provided a conceptual model of the responses of wildlife to recreational activities. They grouped the causes of recreation impacts to wildlife into harvest, habitat modification, pollution, and disturbance.

For this assessment, these two broad classification schemes were refined to focus on road and recreation trail factors that affected wildlife, based on a review of relevant literature. The recreation trail and road associated factors were initially based on the factors developed by Wisdom et al. (1999) and a literature review by Singleton and Lehmkuhl (1998). These reviews were expanded to include additional factors associated with winter and non-winter human use of recreation trails. The relationship between the general classification schemes proposed by Liddle (1997) and Knight and Cole (1995), and the factors used in this assessment are shown in table 1. Table 2 provides a list of the road and trail associated factors along with their definitions and groups of wildlife species that are affected by them.

Based on a review of the scientific literature, road and recreation trail associated factors were identified for "focal" wildlife species for which information was available. The effects of road and recreation trail associated factors can be direct, such as habitat loss and fragmentation, or indirect, such as displacement or avoidance of areas near roads in relation to motorized traffic and associated human activities (Blakesley and Reese 1988, Miller et al. 1998, Reed et al. 1996, Wisdom et al. 2000). Recreation trail associated factors were identified for non-motorized trails, motorized trails, snowmobile routes, and ski trails. In addition, the road-associated factors developed by Wisdom et al. (1999) were summarized and expanded upon.

Step 4. Assessment processes and models-Assessment processes and models were developed to provide a consistent approach to the evaluation of the cumulative effects of roads and recreation trails on wildlife habitats. These were based on the habitat requirements of the focal species and the trail and road associated factors identified to affect the focal species. The models and assessment processes were developed to use geographic information systems (GIS) and corresponding data layers that included roads, trails, wildlife habitats, watersheds and subbasins. Ideally, these models would incorporate the following variables: 1) spatial extent of the immediate effect of the factor (such as distance a species was displaced from a road or trail), 2) the level of intensity of human use on a road or trail that resulted in a factor being identified as affecting the focal species (such as number of people/day or density of roads), and 3) the extent of human influence (assessed by 1 and 2 above) on wildlife habitats within a given area, such as a watershed or subbasin (such as 50% of a watershed within a trail zone of influence with >10 people/day).

Relatively reliable information was available for many focal species concerning the immediate spatial effect of a particular factor. Relatively little information was available relating the intensity of human use to an effect on wildlife and, consequently, it was included in only a few of the models. There was even less information relating the extent of human influence to effects on focal species habitat use, resulting in an area ripe for research. To address cumulative effects in the absence of this kind of information, a relative ranking scheme was used. The relative rankings of assessment areas (watersheds, subbasins, lynx analysis units, etc.) to evaluate the cumulative effects on focal species habitats were based on the assumption that the lower the level of human influence (as measured by the amount of roads and recreation trails) the higher the probability of focal species persistence and the higher the probability that ecosystem processes and functions would be conserved (Fig. 1).

The assessment processes and models described in the document were designed to address broad-scale issues, such as cumulative effects, and to provide information that could be used to evaluate project-level effects. These models could best be viewed as working hypotheses about the interactions between roads, trails and wildlife. As such, wildlife responses should be monitored and models adapted as new information becomes available.

Step 5. Assessment of the current condition-We applied the assessment processes and models to evaluate the current condition of wildlife habitats for each of the focal species relative to the road and recreation trail associated factors. To complete this assessment, district recreation specialists updated GIS based road and trail maps and attributed each trail or trail segment with information on trail use levels. This was completed for all of the recreation trails that occurred in the assessment area.

Step 6. Identification of information gaps-The literature review, model building exercises, and pilot study allowed for the identification of information gaps. These were summarized, prioritized and potential research topics identified.

Step 7. Monitoring and adaptive management-Because of our imperfect knowledge about many of the road, recreation trail and wildlife interactions, assumptions were made to complete the assessment. Appropriate monitoring was identified to test the validity of our assumptions and to make management adjustments based on monitoring results.

Document Organization

The first section of this document provides an overview of the interactions between focal wildlife species and linear recreation routes based on the literature review. The next six sections provide more specific interactions between focal wildlife species and linear recreation routes through species group assessments. The assessments are organized by species group and include the identification of the focal species for each group, road and trail associated factors, and a description of the cumulative effects models. These sections are followed by a case study application of the cumulative effects models for a portion of the Okanagan and Wenatchee National Forests, and include interpretations of model outputs. The final section of this document discusses monitoring and adaptive management, and provides a hypothetical example of how these concepts can be applied to learn from recreation projects that could influence wildlife habitats.

Overview of Interactions between Focal Wildlife Species and Linear Recreation Routes

Introduction
The purpose of this section is to provide an overview and summary of the interactions that were documented in the literature review between the 27 wildlife focal species (table 3), and linear recreation routes. The results of the literature review for focal species by wildlife species group are presented in the following sections.

Literature Review
We identified 193 articles concerning the effects of recreation trails and roads on wildlife. Of these, 176 articles were used to identify the interactions between roads, recreation trails and focal wildlife species. These articles included technical publications, books, agency publications, theses, and dissertations. Many of these references came from previous reviews (Boyle and Samson 1985, Joslin and Youmans 1999, Knight and Gutzwiller 1995, Liddle 1997). The literature that was reviewed for each of the focal species is cited in the following sections by wildlife group and is not repeated here.

Road and focal wildlife species interactions-The science available to describe the interactions between focal wildlife species and roads is more developed than available for recreation trails. Much of the research has been focused on wide-ranging carnivores and ungulates. Other lesser known species could benefit from additional research on the effects of roads and this is especially true for less mobile species where roads may inhibit movements or fragment habitats.

The most commonly reported interactions included displacement/avoidance where animals were reported as altering their use of habitats in response to roads or road networks (fig. 2). Disturbance at a specific site was also commonly reported and included disruption of animal nesting, breeding or wintering areas. Collisions between animals and vehicles were commonly reported and affected a wide diversity of wildlife species, from large mammals to amphibians. Finally, negative edge effects associated with roads or road networks constructed within habitats, especially late-successional forests were commonly identified.

Motorized trails and focal wildlife interactions-Fewer wildlife species have been studied relative to the interactions with motorized trails. Ungulates and some wide-ranging carnivore species were the best studied, and many wildlife could benefit from further research designed to identify these interactions.

The most common interaction identified in the literature includes displacement/avoidance where animals altered their use of habitats in response to motorized trails or trail networks (Fig. 3). Disturbance at a specific site was also identified and, as with roads, was usually associated with wildlife breeding or young-rearing.

Non-motorized trail and focal wildlife species interactions-The most common interactions reported in the literature that we reviewed between non-motorized trails and focal wildlife species were displacement/avoidance which altered habitat use, and disturbance at a specific site during a critical time period (Fig. 4). The interaction of the focal species and motorized or non-motorized trails were quite similar. Depending on the wildlife species, some were more sensitive to motorized trail use, while others were more sensitive to non-motorized trail use. Based on our current level of understanding, both forms of recreation have effects on wildlife. Motorized trails had a somewhat greater magnitude of effects, such as longer distances in which wildlife were displaced, for a greater number of the focal species we reviewed. Additional research would be useful to further refine the interactions of specific species with motorized and non-motorized trails.

Snowmobile route and focal wildlife species interactions-The interactions between snowmobile routes and focal wildlife species are poorly documented for many species. These interactions need to be further refined with additional research and monitoring. The most common interactions that we documented from the literature included trapping as facilitated by winter human access, displacement/avoidance, and disturbance at a specific site, usually wintering areas (fig. 5). An additional interaction that occurred for winter recreation routes was the effect that snow compaction has on the subnivean sites used by small mammals. Small mammals can either be suffocated as a result of the compaction or their subnivean movements can be altered due to impenetrable compact snow. Snow compaction associated with snowmobiling was also identified as altering the competitor/predator communities because the packed snow routes provide winter access to areas not normally available to some species.

Ski trails and focal wildlife interactions-We only documented a few interactions between ski trails and focal wildlife species due to the limited literature available on the subject. Ungulates were the most thoroughly studied group and very few others had been investigated. The most common interactions that we found in the literature included trapping as facilitated by winter route access, displacement avoidance, and disturbance at a specific site (wintering areas in this case) (fig. 6). As with snowmobile routes, ski trails also included the interactions of snow compaction and competitor/predator community alterations.

Information Gaps

Over the course of this review we kept track of information gaps that hindered our understanding of wildlife, road and recreation trail interactions. The following suggested areas of study can be accomplished through the use of an adaptive management approach and well designed monitoring and research (Gaines et al. 1999; Gutzwiller 1991, 1993).

1. The interactions between wildlife, non-motorized trails, snowmobile routes, and ski trails need to be better defined for many wildlife species, especially those with small home ranges and limited mobility.
2. The interactions between wildlife and the intensity of human use on recreation trails (such as trail density or number of hikers/unit time) needs to be better described.
3. The interactions between wildlife habitat use and the spatial extent (such as the proportion of a home range or watershed) of recreational activity are an area that is very poorly understood.
4. Finally, we need to be able to relate recreation trail and wildlife interactions to the demography of a particular species of management interest.

Adaptive management and monitoring designed to lead to greater understanding of any of these areas would greatly facilitate our management goals of conserving ecosystem processes and functions while providing recreation opportunities (see adaptive management and monitoring section).

Management Implications

The information provided in this review, and subsequent development and application of cumulative effects models, will improve the knowledge base that can be used to evaluate project proposals and make informed decisions. The findings of our review collaborate with the findings of other reviews such as those of Boyle and Samson (1985), Joslin and Youmans (1999), Liddle (1997), Pomerantz et al. (1988), and Wisdom et al. (1999). In addition, this information can be used to develop and apply mitigation tools to address the kinds of interactions that have been described for each focal wildlife species or group. Tools that have been used to mitigate recreational activities are described in general terms below and are based, in part, on Colorado State Parks (1998), and Knight and Gutzwiller (1995).

1. <u>Spatial separation of humans and wildlife in key habitats</u>. This approach could be used to address situations where displacement/avoidance interactions have been identified for a wildlife species of management interest.
2. <u>Temporal separation of humans and wildlife at critical time periods</u>. This tool could be applied where the interaction of displacement at a specific site has been identified for a wildlife species of management interest.
3. <u>Human behaviors that reduce the effects of recreation on wildlife</u> can be taught through information and education programs.

4. Design of facilities in wildlife habitats. If wildlife habitat issues are identified upfront in the early stages of projects, they can be addressed proactively through project design. Hopefully, the information provided in this assessment will help accomplish this.

In order to proactively address wildlife conservation and recreation opportunities, we need to begin addressing these issues through our landscape scale planning processes. In this manner important habitats for wildlife and recreational opportunities for humans can be identified. This process could be accomplished using the following approach:

1. Assess the existing level of influence that recreational activities have on wildlife habitats.
2. Set compatible wildlife habitat goals and recreation goals.
3. Gain further knowledge about wildlife and recreation interactions through an adaptive management approach.
4. Adapt habitat and recreation goals based on new information.

The following sections of this document are designed to provide managers with some tools that can be used to evaluate wildlife habitats for various focal wildlife species. In addition, a framework for how to approach adaptive management and monitoring is provided. In this manner, we can address the mutual goals of conserving wildlife species while providing recreation opportunities. These goals have many commonalities, not the least of which is the desire of people to experience “wildlife” during their recreational outings.

Wide-Ranging Carnivore Habitat Assessment

Introduction and Focal Species Selection
There were 9 wildlife species that were included in the wide-ranging carnivore group (see appendix). The species that met the criteria of a focal species for this group included the grizzly bear *(Ursus arctos)*, Canada lynx *(Lynx canadensis),* gray wolf *(Canis lupus)* and wolverine *(Gulo gulo).* These four species were representative of the habitat requirements of the other species in the group, and were sensitive to a wide-array of road and trail associated factors. In addition, three of these species are federally listed and the other, wolverine, has been petitioned (Biodiversity Legal Foundation 2000) for listing and is under review.

Summary of Recreation Associated Factors for Focal Species
Mammals in the order Carnivora have a wide variety of responses to human recreation. Some species, such as coyotes, have adapted to the presence of humans and to human activities (Crabtree and Sheldon 1999). For others, human recreational activities are documented or suspected to have significant adverse impacts (Claar et al. 1999). Because they are listed under the Endangered Species Act and have been the subjects of considerable research, evidence of such impacts is most compelling for grizzly bears and gray wolves (Claar et al. 1999). For several other carnivore species, such as black bear, mountain lion, lynx, bobcat, wolverine, fisher and marten, research has been focused on the demographic effects of hunting or trapping and not on the effects of other recreational activities on their habitats.

Several studies have documented displacement of grizzly bears from trails (motorized and non-motorized) and roads (Archibald et al. 1987; Kasworm and Manley 1990; Mace and Waller 1996, 1998; Mace et al. 1996, 1999; Mattson et al. 1987, McLellan and Shackleton 1988, 1989) (table 4). Factors related to human access include increased potential for poaching, collisions with vehicles, and chronic negative human interactions at campgrounds and campsites that are accessed by roads and trails (Claar et al. 1999, Wisdom et al. 2000) (table 4).

Few studies have been conducted on the effects of recreational activities on lynx (Ruediger et al. 2000). Other focal carnivores appear to be more sensitive to the effects of roads and trails (McKelvey et al. 2000); therefore lynx was selected as a focal species because of concerns about the potential effects of winter recreational activities (Buskirk 1999, Koehler and Aubry 1994, Ruediger et al. 2000). Specifically, snow compaction associated with grooming for snowmobiling and cross-country skiing may provide travel routes for competitors such as coyotes, bobcats, and cougars (Buskirk 1999, Koehler and Aubry 1994, Ruediger et al. 2000) (table 4). Other associated factors include disturbance of den sites during the young rearing period (Claar et al. 1999) (table 4), which is a site-specific issue that should be addressed during project level analysis and planning.

Gray wolves and wolverines are sensitive to road associated factors but are not particularly affected by summer recreation trails (Banci 1994, Boyd and Pletscher 1999, de Vos 1948, Mech et al. 1988, Thurber et al. 1994) (table 4). For gray wolves, both Mech et al. (1988) and Thiel (1985) found that when road densities exceed about 1mi./mi.^{2} wolves avoided or were displaced from areas. Mladenoff et al. (1995) found that road density was the major predictor of wolf pack location. Gray wolves have been documented to abandon den sites if disturbed by humans (Mech et al. 1991) (table 4). It was not possible to identify potential wolf denning habitat at the broad scale for this assessment but it should be addressed at the project level.

Copeland (1996) suggested that winter recreational activities may displace wolverines from important natal dens in subalpine cirques (table 4). The effects of recreation trails on potential wolverine denning habitat will be addressed in this assessment process because of the ability to model potential denning habitat using GIS (Copeland 1996).

Assessment Processes for Focal Species

Grizzly bear assessment model-Cumulative effects models have been developed for grizzly bears (Gibeau 1998, Hood and Parker 2001, Puchlerz and Servheen 1998, Weaver et al. 1987). The model we recommend for use on the Wenatchee and Okanogan national forests (Puchlerz and Servheen 1998) identifies areas of relatively low human use, called core areas, which provide refugium for grizzly bears, within Bear Management Units (BMUs). BMUs have been identified for the portion of the Okanogan and Wenatchee national forests within the grizzly bear recovery zone (USFWS 1997). These areas are generally large enough to provide a variety of seasonal habitats, making them appropriately sized to address cumulative effects.

Core areas are identified by buffering high use trails and open roads by 500 meters on each side. The 500 meter buffer was based on a considerable body of research that shows displacement of grizzly bears from habitats adjacent to roads and high use trails (Kasworm and Manley 1990, Mace and Waller 1996, Mace et al. 1996, Mattson et al. 1987, McLellan and Shackelton 1988) (table 5) and has been used in other cumulative effects models (Hood and Parker 2001, Puchlerz and Servheen 1998). Definitions of high use trails and open roads are provided in table 6. To use this model, roads and trails must be attributed using these definitions and linked to a geographic information system (GIS) for spatial analysis. This model should be applied to assess the effects of roads and recreation trails on grizzly bear habitat on a seasonal basis. Seasons appropriate to the Okanogan and Wenatchee national forests are: early-season – 15 March or den emergence to 31 May, middle-season – 1 June to 15 July, and late-season – July 16 to 31 October or den entrance (NCE Technical Team 1999). Outputs of this model include: 1) the amount of core area within the analysis area, 2) the vegetation types that are represented within the core areas, 3) the effects of trails on the amount of core area, and 4) the effects of roads on the amount of core area.

Once the amount of core area has been determined for the BMU or subbasin influenced by the proposed project, then a relative rating of the level of influence of human activities on grizzly bear habitat can be made. The relative scale is as follows: <55% core area = high level of human influence on the habitat, 55-70% core area = moderate level of human influence on habitat, and >70% core area = low level of human influence on habitat. These levels of core are similar to what has been prescribed in other areas where grizzly bears and human access are being managed (Gibeau 1998, Hood and Parker 2001, Puchlerz and Servheen 1998, USFWS 1993).

Canada lynx assessment model-We have a rudimentary understanding of the effects of recreational activities on Canada lynx (Ruediger et al. 2000). Canada lynx were selected as a focal species to address the potential for snowmobiling and ski-trails to provide routes for competitors such as coyotes, bobcats, and cougars to access lynx habitat (Buskirk 1999, Koehler and Aubry 1994). For lynx, which have relatively narrow habitat preferences (Koehler 1990, McKelvey et al. 2000), Lynx Analysis Units (LAUs) have been identified. These areas have been identified with adequate suitable habitat to support resident lynx (Ruediger et al. 2000) and are an appropriate spatial scale for addressing cumulative effects.

To assess the effects of recreational activities on lynx habitat the density of groomed or commonly used snowmobile routes and ski-trails should be determined using Lynx Analysis Units (LAUs) as the area of analysis. Determine the density of groomed ski and snowmobile routes in an LAU using current GIS data layers for spatial analysis. The outputs of this model include**:** proportion of the LAU with route density <1 mi./mi.^{2}, 1-2 mi./mi.^{2}, >2 mi./mi.^{2}.

Based on the above information, the relative level of human influence on lynx habitat can then be rated. The rating scheme is as follows: <25% of the LAU with ski and snowmobile route densities of <1 mi./mi.^{2} = low level of human influence on lynx habitat, >25% with route densities >1 mi./mi.^{2} = a moderate level of human influence on lynx habitat, and >25% with route densities >2 mi./mi.^{2} = a high level of human influence on lynx habitat. This rating scheme is intended to provide a means of making comparisons between the relative levels of human influence within LAUs. Additional research is needed to determine how increases in groomed ski and snowmobile route density affect lynx habitat use.

Gray wolf and wolverine assessment model-An assessment of the effects of roads and trails on gray wolves and wolverines should be based on an area that approximates their extensive home ranges (Banci 1994, Boyd et al. 1995, Mech 1970). Therefore to address cumulative effects, BMUs should be used for assessments within the grizzly bear recovery zone and 4th field subbasins for areas outside of the recovery zone.

To address the road and trail associated factors identified for gray wolves and wolverines (table 4) three analyses should be conducted to assess the cumulative effects. These include an assessment of the current level of motorized trail and road access within available habitat, the effects of snowmobile routes and ski-trails that occur on deer and elk winter ranges (see Ungulate habitat), and the effects of snowmobile routes and ski trails on potential wolverine denning habitat. No model is currently available for wolf denning habitat.

A moving windows road and motorized trail density analysis using a 1.0 km radius circular window should be used to classify areas as follows: areas with no open roads or motorized trails, areas with densities from 0.1-1.0 mi/mi^2, and areas with densities that are >1 mi/mi^2 within a 4th field subbasin or a BMU. Outputs of this model for each BMU or subbasin include: 1) the amount and location of areas with no open roads or motorized trails, 2) the amount and location of areas with open road and motorized trail densities 0.1-1.0 mi./mi.^{2}, and 3) the amount and location of areas with open road and motorized trail densities >1.0 mi./mi.^{2}.

Based on the above information, the relative level of human influence on gray wolf and wolverine habitat can then be rated. The rating scheme is as follows: <50% of a BMU or subbasin with open road and motorized trail densities <1 mi./mi.^{2} = a high level of human influence on wolf and wolverine habitat, 50-70% with densities <1 mi./mi.^{2} = a moderate level of human influence on wolf and wolverine habitat, >70% with densities <1 mi./mi.^{2} = a low level of human influence on wolf and wolverine habitat.

Potential Wolverine Denning Habitat

The effects of snowmobile routes and ski trails on potential wolverine denning habitat could be assessed using the following model. Current GIS data layers with snowmobile routes and ski trails would be overlaid onto the Land Type Associations (LTAs) (USFS 2000a) which correspond to alpine cirques with the type of structure typically used by wolverines for natal dens (Copeland 1996). These include LTAs Ha7, Ha8, Hb9, and Hi9. The density of snowmobile and ski trails would then be calculated for the potential denning habitat located within a BMU or subbasin. The outputs of this model include potential wolverine denning habitat with groomed winter route densities >1 mi./mi.^{2}, and areas with densities >2 mi./mi.^{2}.

A relative rating of the level of influence of winter recreation routes on potential wolverine denning habitat can than be made using the following scale. A high level of human influence on potential wolverine denning habitat = >25% of the potential habitat within a BMU or subbasin has winter route densities >2 mi/.mi.^{2}, a moderate level of human influence = >25% of the potential habitat within a BMU or subbasin with winter route densities >1 mi./mi.^{2} , and a low level of human influence = <25% of the potential denning habitat within a BMU or subbasin with winter route densities >1 mi./mi.^{2}.

Information Gaps and Research Needs

Research is needed to validate the applicability of the bear and wolf models for use on the Okanogan and Wenatchee national forests since they are based on research conducted in other ecosystems. Specifically, the response of grizzly bears and gray wolves to different levels of human use on trails and roads needs further study (Claar et al. 1999). Research needs to be conducted to determine the direct and indirect effects of recreation on wolverine (Banci 1994) and lynx (Koehler and Aubry 1994, Ruediger et al. 2000), including how snow compaction alters interference competition among lynx, bobcats, and coyotes (Koehler and Aubry 1994). The results of this research could then be used to adapt the assessment models.

Monitoring and Adaptive Management

Habitat effectiveness monitoring-Periodic application of the assessment models for wide-ranging carnivores across the Okanogan and Wenatchee national forests would establish baseline conditions and allow comparisons of habitat effectiveness over time. Information on road and trail status and use levels should be updated at the project level and fed into a forest-wide geographic information system for landscape scale assessment. Monitoring information can then be used to guide adaptive ecosystem management as new science becomes available about the interactions between wide-ranging carnivores and recreation.

Population level monitoring-At this point in time the numbers of grizzly bears, gray wolves, and wolverines may be too low (Almack et al. 1993, Gaines et al. 1995, Gaines et al. 2000a, Gaines et al. 2000b) to effectively monitor their populations. Lynx on the Okanogan National Forest could provide a situation where numbers are high enough for population monitoring. These methods are currently being developed and implemented (McKelvey et al. 1999).

Ungulate Winter and Summer Habitat Assessment

Introduction and Focal Species Selection
There are six wildlife species included in the ungulate group and these include mule deer, white-tailed deer, elk, moose, bighorn sheep, and mountain goats. The focal species selected to represent the effects of roads and recreational activities on ungulates include mule deer *(Odocoileus hemnionus)*, elk *(Cervus elephus)*, and bighorn sheep *(Ovis canadensis).* These species were selected because their habitat needs and response to recreation trails and roads were representative of the group, and because habitat effects are possible to monitor. Additionally, the bighorn sheep is listed as a Sensitive species.

Summary of Recreation Associated Factors for Focal Species
Mule deer and elk respond to recreational activities by avoiding areas in close proximity to road and recreation trails (tables 7, 8) (Cassirer et al. 1992, Ferguson and Keith 1982, Freddy et al. 1986, Rowland et al. 2000). Ski trails seem to displace mule deer to greater distances than occurs along snowmobile routes (table 8) (Cassirer et al. 1992, Freddy et al. 1986). Freddy et al. (1986) reported that mule deer displacement by skiers was independent of skier numbers or group size. Elk, however, moved away from ski trails only when use was >8 persons/day (Ferguson and Keith 1982).

Elk responded to persons on foot by moving away from trails and the distance of this displacement was quite variable among study areas (Cassier et al. 1992, Ferguson and Keith 1982, Schultz and Bailey 1978). Johnson et al. (2000) showed that as the volume of traffic increased on roads the mean distance that elk were located from roads also increased (table 8). Elk reproductive success has been shown to decrease following human disturbance to calving areas (Phillips and Alldredge 2000). Cole et al. (1997) showed that road closures were successful in reducing the effects of habitat displacement and increasing elk survivorship.

Bighorn sheep have also been reported to respond to human disturbance (Hicks and Elder 1979, King and Workman 1986, Macarthur et al. 1982, Papouchis et al. 2001). Macarthur et al. (1982) reported that sheep were affected by a human approaching within 50 meters. Papouchis et al. (2001) found that bighorn sheep responded to hikers at an average distance of 200 meters. They also showed that avoidance of heavy road traffic was greater for high use (5-13 vehicles/hour) versus low use (1 vehicle/hour) areas. On average radio-collared sheep were 490 meters from high use roads compared to 354 meters from low use roads (Papouchis et al. 2001).

Human activities are of particular concern for ungulates when they occur on their winter ranges or young rearing areas (Canfield et al. 1999). Young rearing areas may be best evaluated at the site-specific project level.

Assessment Processes for Focal Species

Winter habitat influence index for mule deer and elk-To evaluate the cumulative effects of roads and recreation trails on mule deer and elk these activities should be assessed during the winter when disturbance has the potential to be the most detrimental (Canfield et al. 1999). This means evaluating the effects of roads, ski trails, and snowmobile routes on the winter ranges for these species. Winter ranges for mule deer and elk on the Okanogan and Wenatchee national forests generally occur at lower elevations and are usually distinct units separated by private lands and higher elevation non-winter habitats. To address cumulative effects the entire unit of winter range habitat should be evaluated and the area should be at least 800-1,200 ha in size (Lyon 1983).

An index of habitat effectiveness applied to the winter range habitat unit can be calculated using GIS with current data layers showing plowed roads, ski trails and snowmobile routes. Because of the differing effects of these activities, different buffers would be applied to each to evaluate the amount of affected habitat. For roads the zone of influence would be 800 meters on each side of a plowed road, for ski trails that receive use >8 persons/day the zone of influence would be 200 meters on each side, and for snowmobile routes the zone would be 150 meters on each side of the route. Using this approach, the proportion of the winter range that is influenced by winter recreation is determined. Model outputs include the proportion of winter range influenced by roads, proportion of the winter range influenced by ski trails, and the proportion of the winter range influenced by snowmobile routes. The summed relative effects of these activities are then rated using the following scale: >70% of the winter range outside of a zone of influence rates as a low level of human influence on deer and elk winter range, 50-70% of the winter range outside of a zone of influence is classified as a moderate level of human influence, and <50% outside of the zone of influence rates as a high level of human influence.

Summer or winter habitat influence index for bighorn sheep-To assess the effects of road and recreational trail associated factors on bighorn sheep a summer and/or winter range habitat effectiveness index is calculated. To calculate this index GIS maps of their winter and summer ranges are needed. For the winter index GIS layers of current roads and their use levels, ski trails, and snowmobile routes are used. For the summer index roads and their use levels, motorized trails, and non-motorized trails GIS layers area used. Roads which receive ≤1 vehicle/day and other motorized routes are buffered by a 350 meter zone of influence and those with >1 vehicle/day a 500 meter zone of influence (table 9). Groomed ski trails and hiking trails are buffered by 200 m on each side (table 9). The proportion of the summer and/or winter range that is influenced by road and trail recreation activities is then determined. Model outputs include the proportion of summer or winter range influenced by roads, proportion of the summer or winter range influenced by trails, and the proportion of the summer or winter range influenced by motorized trail routes. The relative effects of these activities is then rated using the following scale: >70% of the range outside of a zone of influence rates as a low level of human influence on bighorn sheep summer or winter range, 50-70% of the summer or winter range outside of a zone of influence is classified as a moderate level of human influence, and <50% outside of the zone of influence rates as a high level of human influence.

Summer habitat influence index for deer and elk-Previous generations of deer and elk habitat effectiveness models have used road density as an index for summer ranges. However, Roloff (1998) and Rowland et al. (2000) have recommended that a spatially explicit roads variable, based on distance to open roads, may be more appropriate. In addition, Johnson et al. (2000) showed that different levels of traffic can have different degrees of influence on deer and elk habitat use. Therefore, to evaluate the cumulative effects of road and motorized trails on deer and elk summer ranges roads and motorized trails would be buffered by the distances shown in table 10. These buffers would be applied to all of the roads in a 5th field watershed and the proportion of the habitat in the watershed would be determined. Next, using the "seen" function in ARCInfo and digital terrain data, the portion of the area within the road buffer that is visible from the road is determined. This becomes the portion of the watershed that is influenced by roads. This number is then divided by the total area in the watershed to estimate the percent within a zone of influence. A relative ranking of the level of road and trail influences on deer and elk summer range is then applied as follows: >70% of the summer range outside of a zone of influence = a low level of human influence on deer and elk summer range, 50-70% of the summer range outside of a zone of influence = a moderate level of human influence, and <50% outside of the zone of influence = a high level of human influence.

Information Gaps and Research Needs
Additional research is needed on the effects of roads and snowmobiles on bighorn sheep during the winter. The most efficient method to accomplish this would be through the use of telemetry or observational studies conducted during the winter. All ungulate focal species could benefit from research that links the effects of recreation trails and roads to the demography of the focal species. Research on this subject has been most intensively focused on elk, and other species would benefit from similar efforts.

Monitoring and Adaptive Management

Habitat monitoring-Periodic application of the assessment models would allow trends of habitat effectiveness to be tracked over time. In addition, monitoring could be used to validate the zone of influence estimates to site-specific conditions (Roloff et al. 2001). This could be done using radio-telemetry (White and Garrot 1990), snow tracking, or pellet group indices (Wemmer et al. 1996).

Population monitoring-Population monitoring of ungulates is generally carried out by state agencies relying on aerial counts conducted during the winter when animals are concentrated on their winter ranges. These data provide information on general trends of ungulate populations.

Late-Successional Forest Habitat Assessment

Introduction and Focal Species Selection

A total of 71 species were included in the late-successional forest habitat species group (see appendix). The focal species that were selected for this group include species associated with mixed-conifer late-successional forests such as the northern spotted owl *(Strix occidentalis caurina)*, northern goshawk *(Accipiter gentilis)*, brown creeper *(Certhia americana),* American marten *(Martes americana)*, fisher *(Martes pennanti)*, and the northern flying squirrel *(Glaucomys sabrinus)*. Additional species were selected that are associated with old ponderosa pine forests and they include the pygmy nuthatch *(Sitta pygmaea)*, white-breasted nuthatch *(Sitta carolinensis)*, and white-headed woodpecker *(Picoides albolarvatus)*. These species were selected because they represent a wide-array of road and recreation trail associated factors, and late-successional habitats (table 11).

Focal Species Road and Trail Associated Factors

There is very limited information available concerning the effects of winter and non-winter recreation trails on many of the wildlife species associated with late-successional habitats. More studies have documented the effects that roads can have on these species.

Northern spotted owls could be affected by the negative edge effects of roads (USFS 1997). Swarthout and Stiedl (2001) reported that the closely related Mexican spotted owl *(Strix occidentalis lucida)* was affected by hikers. They reported that juveniles and adults were unlikely to flush at distances $\geq$12 meters and $\geq$24 meters from hikers, respectively.

Human disturbances to goshawk nests have been a suspected cause of nest abandonment (Reynolds et al. 1992). Grubb et al. (1998) reported that vehicle traffic from roads caused no discernable behavioral response by goshawks at distances >400 m from nest sites in forested habitats with noise levels <54 decibels. Critical times for human disturbance to be evaluated include the nesting period and post-fledgling periods for goshawks. The post-fledgling area is an area of concentrated use from the time the young leave the nest until they are no longer dependent on the adults for food. Jones (1979) recommended a 400-500 meter radius spatial buffer around goshawk nest sites to protect them from disturbance during 1 March to 30 September. Additional road and recreational trail associated factors identified for goshawks include negative edge effects from roads and disturbance at a specific site (nest site) (table 11) (Hamann et al. 1999, Wisdom et al. 2000).

There is evidence to suggest that roads may result in the loss or fragmentation of habitat for brown creepers (table 11). For example, Hutto (1995) found that brown creepers were twice as likely to occur in habitats that were more than 100 m from a road. Keller and Anderson (1992) found that brown creepers were associated with larger forest patches. Foppen and Reijnen (1994) found that roads and motorized trails influenced forest bird reproduction to a distance of 200 m. In addition, roads and recreation trails may breakup forest patches and increase nest predation and parasitism rates by species such as cowbirds (Hickman 1990, Miller et al. 1998). Trails used for hiking can also influence forest bird habitat use. Miller et al. (1998) reported a zone of influence of 100 meters for some forest bird species.

Fisher and marten are known for their vulnerability to trapping and susceptibility to overharvest (Powell 1979, 1982; Weaver 1993). Roads and trails, especially snow mobile trails, developed for recreation are also used by trappers and, therefore, increase vulnerability of these species to trapping mortality (Claar et al. 1999). Other road and trail associated factors included snag and downed log reduction, negative edge effects, collisions and habitat loss/fragmentation (table 11) (Claar et al. 1999, Wisdom et al. 2000).

Northern flying squirrels play important ecological roles is late-successional forests (Carey 1991, 1995) and are therefore included as a focal species. The road associated factors for the northern flying squirrel included snag and downed log reduction, and negative edge effects (table 11) (Wisdom et al. 2000). No trail associated factors were identified in the literature that we reviewed.

Pygmy nuthatch, white-breasted nuthatch, and white-headed woodpecker are affected by the removal of snags along roads for firewood and safety, and the negative edge effects of roads to their habitats (table 11) (Wisdom et al. 2000). No recreation trail associated factors were identified for white-headed woodpeckers (Hamann et al. 1999). Roads and recreation trails may influence pygmy nuthatch and white-breasted nuthatch habitat use. For example, Foppen and Reijnen (1994) found that roads and motorized trails influenced forest bird reproduction to a distance of 200 m. Miller et al. (1998) reported a zone of influence of 100 meters along trails used for hiking for some forest bird species

Assessment Processes for Focal Species

Habitat for late-successional associated species within the range of the northern spotted owl is managed within a network of reserves (USFS 1994). On the Wenatchee and Okanogan national forests these reserves are called Late-Successional Reserves (LSRs) and Managed Late-Successional Areas (MLSAs). This network of reserves was designed to provide for the viability of late-successional species (Thomas et al. 1993). When projects are proposed within one of these reserves the cumulative effects of roads and trails on habitat effectiveness within the reserve should be assessed (USFS 1997). Reserves should be at least 10,000 acres in size to adequately address cumulative effects. Reserves smaller than this can be grouped by including adjacent reserves until an adequately sized area is reached. Projects that are not located in a reserve but could affect late-successional habitats and species should be addressed using late-successional habitat within a 5th field watershed as the analysis area.

In the Wenatchee National Forest Late-Successional Reserve Assessment (WNFLSRA) (USFS 1997) two indices to assess habitat effectiveness within LSRs and MLSAs were identified. These included the overall open road density within the LSR and the amount of security habitat. Security habitat was defined as areas that were greater than 500 m from an open road. The WNFLSRA did not consider the effects of recreation trails within LSRs and MLSAs on habitat effectiveness for late-successional species. However, as a result of this review, the assessment model that is described below includes recreation trails, both winter and non-winter, and should be viewed as an update to the security habitat model originally developed in the WNFLSRA (USFS 1997).

Non-winter habitat influence index-The assessment process to evaluate roads and recreational trails on habitat effectiveness for late-successional species should be divided into winter and non-winter time periods. For the non-winter period a habitat influence index and security habitat index should be calculated for the late-successional habitat in a LSR, MLSA, or 5th field watershed in which the project is located. The habitat influence index is designed to address negative edge effects, snag and downed log reduction, and habitat loss/fragmentation road associated factors. This index is calculated using GIS with a current open roads data layer and late-successional habitat layer. Open roads are buffered by 150 feet (50 meters) on both sides and the area within this buffer is determined for the entire LSR, MLSA or late-successional habitat in a 5th field watershed. This number is then divided by the total amount of late-successional habitat in the LSR, MLSA, or in a 5th field watershed to determine the proportion late-successional habitats that could be influenced by open roads.

Once the Habitat Influence Index has been calculated then the relative level of influence of road associated factors on late-successional habitat can be determined. The scale used to determine the level of influence is as follows: <30% within habitat influence buffer = a low level of human influence on late successional habitats, 30-50% = a moderate level of influence on late-successional habitats, and >50% = a high level of influence on late-successional habitats.

Non-winter security habitat-The second non-winter index is a modification of the security habitat index described in the WNFLSRA (USFS 1997). This index is used to evaluate the effects of displacement/ avoidance, disturbance, and human access that can lead to trapping. This index is calculated using GIS and current trail and open road data layers. Open roads and motorized trails are buffered by 200 m (Foppen and Reijnen 1994, Hamann et al. 1999, Hutto 1995) and non-motorized trails are buffered by 100 m (Hamann et al. 1999, Miller et al. 1998). The area outside of this buffer, referred to as security habitat, is determined for late-successional habitat in a LSR, MLSA, or in a 5th field watershed. This number is then divided by the total area in late-successional habitat in a LSR, MLSA, or 5th field watershed to determine the proportion that is in security habitat and may provide refugium for some late-successional associated species.

Once the amount of late-successional security habitat has been determined for the LSR, MLSA, or 5th field watershed, then a relative rating of the level of influence of human activities on late-successional habitat can be made. This scale is as follows: <50% security habitat = high level of human influence on the late-successional habitat, 50-70% security habitat = moderate level of human influence on late-successional habitat, and >70% security habitat = low level of human influence on late-successional habitat.

Winter security habitat-To evaluate the effects of winter recreation trails a winter security habitat index should be calculated. This index is calculated using GIS and a current data layer showing plowed roads, ski trails and snowmobile routes within the late-successional habitat in a LSR, MLSA or 5th field watershed. Plowed roads, ski trails and snowmobile routes are buffered by 200 meters on each side and the area outside of this buffer is referred to as winter security habitat. This number is then divided by the total area of late-successional habitat in the LSR, MLSA, or 5th field watershed to determine the proportion of the late-successional habitat in the LSR, MLSA, or 5th field watershed that is late-successional winter security habitat.

Once the amount of late-successional winter security habitat has been determined for the LSR, MLSA, or 5th field watershed, then a relative rating of the level of influence of human activities on late-successional habitat can be made. This scale is as follows: <50% winter security habitat = high level of human influence on late-successional habitat, 50-70% winter security habitat = moderate level of human influence on late-successional habitat, and >70% winter security habitat = low level of human influence on late-successional habitat

Information Gaps and Research

There is currently a lack of information on the effects of recreational trails on many of the wildlife species that are associated with late-successional habitats. This makes it difficult to develop good management strategies or to assess the effects of projects on these species. Specifically the influence of recreation trails on space-use patterns of late-successional species at different levels of recreation use and for different types of uses needs to be studied. Research that links the effects of recreational activities to the demography of late-successional species would be especially valuable.

Monitoring and Adaptive Management

Until additional research becomes available, the assessment processes identified should be considered as working hypotheses upon which monitoring could be designed to test their validity. For example, the influence that roads have on the availability of late-successional habitat structure adjacent to roads as a result of snag cutting and tree felling for firewood or traffic safety could be monitored to determine the validity of the habitat loss index. In addition, the concept of security habitat could be evaluated by monitoring the demography of focal late-successional species in areas identified as security habitat compared to those in areas that are not security habitat.

Habitat effectiveness monitoring-The habitat influence index and the security habitat indices could be used to establish baseline levels of habitat effectiveness within LSR, MLSAs, and late-successional habitat in a 5th field watershed. Periodic application of these models could show trends in habitat effectiveness over time.

Population monitoring-Monitoring of focal late-successional species within LSRs and MLSAs could be used to monitor habitat effectiveness in relation to species abundance. For example, protocols have been developed to survey and locate goshawk nest sites and monitor their productivity (Watson et al. 1999). Brown creepers, pygmy nuthatches, white-breasted nuthatches, and white-headed woodpeckers can be monitored using point counts (Ralph et al. 1993) or nest searches could be conducted to evaluate productivity (Ralph et al. 1993). American marten and fisher populations can be indexed using track plate surveys (Zielinski and Kucera 1995). These protocols could be used to monitor focal late-successional species populations within different late-successional habitats.

Riparian Habitat Assessment

Introduction and Focal Species Selection

There were 144 wildlife species in the riparian habitat species group (see appendix). The focal species identified for this group includes the Cascade frog *(Rana cascadae)*, tailed frog *(Ascaphus trueii)*, Harlequin duck *(Histrionicus histrionicus)*, bald eagle *(Haliaeetus leucocephalus)*, and water shrew *(Sorex palustris).* These species were selected because they represent a diversity of riparian habitats, and road and trail associated factors (table 12).

Focal Species Road and Trail Associated Factors

Wildlife species associated with riparian habitats are particularly vulnerable to the effects of recreational activities on their habitats because of the concentration of these activities in riparian areas. Riparian habitats occur in a linear configuration within watersheds and are often traversed by roads and trails. In addition, riparian habitats are used by a wide variety of wildlife species and are used disproportionately more than they are available (Thomas et al. 1979).

The road and trail associated factors for the Cascade frog and tailed frog included collisions, habitat loss/fragmentation and movement barriers/filters (table 12) (Ashley and Robinson 1996, DeMaynadier and Hunter 2000, Fahrig et al. 1995, Gibbs 1998, Rei and Seitz 1990, Welsh and Ollivier 1998, Wisdom et al. 2000, Yanes et al. 1995).

Studies have repeatedly shown that Harlequin ducks are sensitive to human disturbances during the breeding season (Hamann et al. 1999). Ashley (1994) found that Harlequin ducks used streams habitats inaccessible to humans more than expected. Wallen (1987) reported that fishing along trails seemed more disruptive than hiking. Harlequins avoided humans on the bank or in the streambed and would typically swim or dive downstream past people, remaining partially submerged and watchful while moving out of the area. Fishing also has a direct effect on Harlequin ducks as birds have been found entangled in fishing line (Ashley 1994, Clarkson 1992). The road and recreation trail associated factors that were identified for the Harlequin duck include snag reduction, disturbance at a specific site (nest site), displacement/avoidance, and habitat loss/fragmentation from roads (table 12) (Hamann et al. 1999, Wisdom et al. 2000).

The response of bald eagles to human activities is quite variable. Reported responses have included spatial avoidance of activity and reproductive failure (Hamann et al. 1999), although in some cases, eagles tolerate human disturbances (Harmata and Oakleaf 1992). The road and recreation trail associated factors that were identified in this review included poaching, disturbance at a specific site, and avoidance/displacement (table 12) (Skagen et al. 1991, Stalmaster and Newman 1978). Bald eagles seem to be more sensitive to humans afoot than to vehicular traffic (Hamann et al. 1999, Skagen et al. 1991, Stalmaster and Newman 1978).

The water shrew is known to be associated with riparian habitats and occurs at high enough densities to make it a good candidate for monitoring (Peffer 2001). The road and recreation trail associated factors for the water shrew include collisions, movement barriers/filters, habitat loss/fragmentation, downed log reduction, displacement/avoidance, and snow compaction (table 12) (Baldwin and Stoddard 1973, Cole and Landres 1995, Hickman 1999, Knight and Cole 1991, Randgaard 1998, Schmid 1972). Snow compaction from snowmobiling and ski trail grooming has been cited to cause mortality and to present barriers to small mammal movements in subnivean spaces (Schmid 1972).

Assessment Processes for Focal Species

To evaluate the cumulative effects of roads and recreation trails on riparian associated species the evaluation area should be the 5th field watershed in which the proposed project is located. Riparian reserves (RR) or riparian habitat conservation areas (RHCAs) are management allocations designed to provide a variety of functions for aquatic and terrestrial species (USFS 1994). For terrestrial species these include providing habitat and connectivity between habitat patches (USFS 1994).

Non-winter habitat influence index-The assessment process to evaluate the effects of roads and recreational trails on riparian habitats should be divided into winter and non-winter time periods. For the non-winter period a habitat influence index should be calculated for all of the RRs or the RHCAs within the watershed. The habitat influence index is designed to address negative edge effects, snag and downed log reduction, and habitat loss/fragmentation road associated factors. This index is calculated using GIS and a current open roads data layer. Open roads are buffered by 60 meters on both sides and the area within this buffer is determined for the entire area that is within RRs or RHCAs in a watershed. The 60 meter buffer is based on information presented in Hamann et al. (1999) on the degree of habitat affected by woodcutting along roads. The area within the buffer is then divided by the total area within RR or RHCA in the watershed to determine the proportion of the riparian habitat influenced by open roads. A relative rating is then calculated to determine the extent of recreation activities on riparian habitats. The relative rating is as follows: <30% of the RR or RHCA in an open road buffer = a low level of human influence on riparian habitats, 30-50% = a moderate level, and >50% is rated as a high level of human influence on riparian habitats.

Non-winter route density index-In addition to the habitat influence index, the density of open roads, motorized trails and non-motorized trails within RRs or RHCAs should be calculated for the watershed using a moving window analysis with a 1km circular window. This index is used to evaluate the level of disturbance to wildlife from recreational activities. A high level of human influence on riparian habitat = >25% of the riparian habitat within a watershed has route densities >2 mi/.mi.^{2}, a moderate level of human influence = >25% of the riparian habitat within watershed with route densities >1 mi./mi.^{2} , and a low level of human influence = <25% of the riparian habitat within a watershed with route densities >1 mi./mi.^{2}.

Winter recreation route density index-For the winter time period, the density of groomed ski trails and snowmobile routes within RRs or RHCAs in the watershed should be calculated using a moving window analysis with a 1km circular window. This provides an index of the effects of winter recreation routes on riparian habitats. A high level of human influence on riparian habitat = >25% of the riparian habitat within a watershed has route densities >2 mi/.mi.^{2}, a moderate level of human influence = >25% of the riparian habitat within watershed with route densities >1 mi./mi.^{2} , and a low level of human influence = <25% of the riparian habitat within a watershed with route densities >1 mi./mi.^{2}.

Information Gaps and Research

More research is needed to develop a more thorough understanding of the influences of road and trail associated factors on riparian species, particularly research that links human uses to effects on animal population demographics. Specifically, research needs to be conducted to determine the extent to which roads and recreation trails serve as dispersal barriers or filters for amphibians and small mammals. A more complete understanding of the influences that road and recreation trails have on Harlequin duck reproduction and survival is needed. For example, a better understanding of the relationship between the intensity of human use and its effects on Harlequin duck reproduction would be helpful to design effective management strategies.

Monitoring and Adaptive Management

Habitat monitoring-Application of the assessment models for riparian associated species could be applied periodically to assess trends in the influence of roads and recreation trails on riparian habitats. Validation monitoring needs to be implemented to determine the validity of the assessment models and link them to population demographics of the focal riparian species.

Population monitoring- Populations of Cascade frogs and small mammals could be monitored using pitfalls traps (Jones 1986, Jones et al. 1996) within riparian habitats that are influenced by road and trail associated factors, and compared to areas not influenced (to serve as controls). Specific locations where frogs disperse across roads should be monitored for road specific mortality and to determine if management changes are needed. Populations of Harlequin ducks could be surveyed following the U.S. Forest Service survey protocol and a comparison made between areas with roads and recreation trails compared to those without. A few bald eagle nest sites have been located on the Okanogan and Wenatchee national forests and they are being monitored as part of Forest Plan monitoring.

Waterfowl and Colonial Nesters Associated With Large River and Lake Habitat Assessment

Introduction and Focal Species Selection
A total of 97 wildlife species are in this group (see appendix). Focal species that were selected included the common loon *(Gavia immer)*, great blue heron *(Ardea herodias)*, eared grebe *(Podiceps nigricollis)*, and wood duck *(Aix sponsa)*. Loons use large rivers and lakes as nesting habitat and are listed as a Sensitive species. The eared grebe uses ponds and lakes up to the ponderosa pine zone and is also listed as a Sensitive species. Great blue herons use lowland rivers, and wood ducks nest in cavities adjacent to small ponds and lakes. Together, these species represent a variety of habitats, and road and trail associated factors (table 13).

Summary of Road and Recreation Trail Associated Factors
Human disturbance is known to negatively affect waterfowl and colonial waterbirds (Anderson 1988, Belanger and Bedard 1989, Boellstorff et al. 1988, Gotmark and Ahlund 1984, Henson and Grant 1991, Madsen 1985, Owens 1977, Pierce and Simons 1986, Tremblay and Ellison 1979). These studies have shown that disturbance can affect productivity in a number of ways including nest abandonment, egg mortality due to exposure, increased predation of eggs and hatchlings, depressed feeding rates on wintering and staging grounds, and avoidance of otherwise suitable habitat.

The common loon, great blue heron, eared grebe and wood duck can be influenced by several forms of human activities (Hamann et al. 1999). The road and recreation trail factors associated with these species included disturbance during nesting and displacement from habitat (table 13) (Ashley 1994, Hamann et al. 1999, Kelly 1992, Klein 1993, Markham and Brechtel 1978, McEneaney 1994, Rodgers and Smith 1995, Titus and VanDruff 1981, Vos et al. 1985, Wallen 1987, Werschkul et al. 1976). Titus and VanDruff (1981) reported that population characteristics, nest and egg production, nest and egg losses, flushing distances, and hatching and brood rearing success for common loons was not significantly different between areas of high and low human use. Wood ducks nest in cavities and can be affected by the loss of snag habitat associated with roads (Hamann et al. 1999). No ski or snowmobile route associated factors were identified for these species as winter recreation generally occurs after the nesting and young rearing periods when they are the most susceptible.

Assessment Processes for Focal Species
To evaluate the cumulative effects of roads and recreation trails on nesting and habitat use the assessment model described below would be applied at the 5th field watershed scale. Potential nesting habitats such as lakes, rivers and ponds should be identified within a watershed and put into GIS. A 250 meter habitat zone is then placed around each of the identified habitats and the area within this zone is summed for the watershed. These habitats are then overlaid with roads, motorized trails, and non-motorized trails. Roads and recreation trails are then buffered by a 250 meter zone of influence on each side. The proportion of the habitat zone that lies outside of a zone of influence of a road or trail is then determined. The 250 meter zone of influence is based on distances at which birds have been observed to be affected by human disturbances (Hamann et al. 1999, Kelly 1992, Markham and Brechtel 1978, Rodgers and Smith 1995, Vos et al. 1985). Outputs of this model include the proportion of potential habitat by watershed affected by road associated factors, proportion of potential habitat in a watershed affected by motorized trails, proportion of potential habitat in a watershed affected by non-motorized trails, and the overall influence of roads and trails.

Hamann et al. (1999) reported that when over half of the available habitat around a lake was disturbed by human activities loons did not nest. This estimate was used to establish a relative ranking of the level of human influence on habitats of the focal species within a given watershed. The relative ranking is as follows:<50% of the potential habitat outside of the zone of influence of a road or trail = high level of human influence, 50-70% of the potential habitat in a zone of influence = moderate level of human influence, and >70% = a low level of human influence.

Information Gaps and Research Needs
Additional research is needed to relate road and trail associated factors to demographic responses of the focal species. In addition, research that explores how different types and intensities of road and trail uses affect focal waterfowl species would allow for the refinement of the cumulative effects models.

Monitoring and Adaptive Management

Habitat effectiveness monitoring-The cumulative effects model described for these focal species could be used to establish baseline conditions for their habitats within watersheds. These models could then be periodically applied to monitor trends in human influences on habitat over time.

Population monitoring-The numbers and breeding success of the focal species for this group could be monitored by selecting representative lakes, ponds and rivers that have different levels of human activities adjacent to them. In this manner, population trends could be monitored and these trends could be correlated to different levels of human activity.

Primary Cavity Excavator Habitat Assessment

Introduction and Focal Species Selection
A total of 11 species were included in the primary cavity excavator (PCE) group (see appendix). The species selected as focal species included the white-headed woodpecker *(Picoides albolarvatus)*, three-toed woodpecker *(Picoides tridactylus)*, and pileated woodpecker *(Drycopus pileatus)* (table 14). The white-headed woodpecker was selected because of its association with old ponderosa pine forests, three-toed woodpeckers with subalpine fir forests, and pileated with mixed conifer forests.

Focal Species Road and Trail Associated Factors
Only road associated factors were identified for these species as the available literature did not suggest that recreation trail associated disturbances presented a problem for primary cavity excavators (Hamann et al. 1999). Recreational activity is unlikely to be focused around the nest sites of these species and, by design, woodpeckers and other cavity users are relatively more secure from nest predation than any other group of forest birds (Hamann et al. 1999). Therefore, recreational disturbance is not known to be a major limiting factor at this time.

The road associated factors included the negative edge effects of roads on PCE habitat and snag and down log reduction resulting from wood cutting and safety practices along roads (table 14) (Bull and Holthausen 1993, Hitchcox 1996, Hutto 1995, Milne and Hejl 1989, Raphael and White 1976). The distances in which woodcutters can harvest snags from roads vary according to terrain. Distances reported by Hamann et al. (1999) ranged from 65 to 200 meters.

Assessment Processes for Focal Species
The assessment processes to evaluate the cumulative effects of road associated factors on primary cavity excavators would be applied to the 5^{th} Field watershed. Open roads in a watershed that occur within forested habitats are buffered by 60 meters on each side to determine the potential influence on cavity excavator habitat. The forested habitats within this buffer is then determined and divided by the total amount of forested habitat within the watershed. In this manner, an index to the proportion of primary cavity excavator habitat influenced by roads within a watershed is derived. A relative ranking is then determined based on the following scale: <30% of forested habitat in an open road buffer = a low level of human influence on primary cavity excavator habitat, 30-50% = a moderate level of influence, and >50% = a high level of influence.

Information Gaps and Research
Research is needed to link road associated factors to the demography of the focal species for this wildlife group. Additional research is needed to validate the assumption that recreation trails are not a limiting factor for primary cavity excavator populations.

Monitoring and Adaptive Management

Habitat monitoring-The habitat influence index for primary cavity excavators could be applied periodically to determine baseline conditions and track the changes to habitat over time. Monitoring needs to be completed to validate the zone of influence along roads in primary cavity excavator habitat. This could be done by sampling habitat structure at varying distances from roads in a variety of forested habitat types.

Population monitoring-Populations of primary cavity excavators could be monitored using point counts (Bull et al. 1990, Huff et al. 2001) established in a variety of habitats and in areas with and without road and recreation trail associated factors.

Application of the Recreation Route Cumulative Effects Models: A Case Study

Introduction
The purpose of this section is to illustrate how cumulative effects of linear recreation routes on wildlife habitats can be assessed using the GIS models developed in the previous sections. This section is intended to display current conditions relative to the influences that linear recreation routes have on various wildlife habitats, which in turn provides a baseline of information for future planning efforts. Finally, this section discusses the results and management implications of applying the proposed cumulative effects models.

Assessment Area
The assessment area includes all of the lands that lie to the east of the crest of the North Cascades between Lake Chelan and the I90 Highway Corridor, extending east to the Columbia River (fig. 7). This area provides a diversity of winter and non-winter recreation opportunities and a diversity of wildlife habitats making it an excellent area to "test drive" the proposed cumulative effects process. The area includes 11 Bear Management Units (BMUs), 22 Lynx Analysis Units (LAUs), 9 ungulate winter range units, 15 Late-Successional Reserves (including managed late-successional areas), and 19 5th field watersheds.

Assessment Models Applied
All 16 of the GIS cumulative effects assessment models were used to evaluate wildlife habitats within the case study area (table 15). Four of the models were used to evaluate winter recreational activities on wildlife habitats, 11 models for the non-winter time periods, and one model, the wolverine denning model, included winter and spring time periods.

Results and Discussion

Wide- ranging carnivore habitats-During the early-season 36% of the BMUs were rated as a high level of human influence, 27% as moderate, and 36% as low (table 16). During the mid and late-seasons trails became snow free and received enough use to be classified as "high use" trails resulting in a higher proportion of BMUs with a high level of human influence. Sixty-four percent of the BMUs were ranked as high level of human influence, 18% as moderate, and 18% as low (table 16). This analysis suggests that cumulative effects are more of an issue for grizzly bear habitats during the mid and late-seasons within the assessment area. Cumulative effects could be reduced through access management and these opportunities could be identified during roads analysis (USFS 2000c). Seasonally important habitats to be considered for inclusion in core areas have been identified for each of these BMUs in the North Cascades Ecosystem grizzly bear habitat assessment (NCETT 2001).

During the non-winter period, 36% of the assessment areas for gray wolf and wolverine habitats were ranked as having a high level of human influence, 36% as moderate, and 27% as low (table 17). Cumulative effects were more of an issue during the non-winter season based on this analysis. Habitat effectiveness could be restored through road access management and opportunities could be identified during roads analysis (USFS 2000c). During the winter all of the assessment areas were ranked as having a low level of human influence from groomed or designated winter recreation routes (table 18). This assessment did not include winter routes that are not groomed or officially designated such as snowmobile routes or snow play areas.

The assessment of cumulative effects of groomed and designated winter recreation routes on lynx habitats showed that 4% of the LAUs had a high level of human influence, 20% had a moderate level, and 76% had a low level (table 19). Based on this analysis cumulative effects are a significant issue within one of the LAUs in the assessment area. This assessment did not include winter routes that are not groomed or officially designated such as snowmobile routes or snow play areas.

Ungulate winter and summer habitats-The assessment of cumulative effects on deer and elk habitats showed that during non-winter periods ??% of the assessment units had a high level of human influence,

??% had a moderate level, and ??% had a low level (table 21). During the winter period groomed and designated winter recreation routes had lower levels of cumulative effects. None of the winter ranges had a high level of human influence, 10% had a moderate level, and 90% had a low level (table 20). This same trend occurred for bighorn sheep. Assessment units for non-winter habitats showed one with a high level and one with a moderate level of human influence (table 22), while during the winter both ranked as low levels (table 23). The cumulative effects of non-winter recreation routes on deer and elk habitat could be reduced through management of roads. Opportunities to enhance deer and elk habitat effectiveness through road management could be addressed during roads analysis (USFS 2000c). Only groomed and designated routes were considered in this assessment. Other routes may occur and could contribute to cumulative effects.

Late-successional forest habitats-The results of applying the cumulative effects models to late-successional habitats within Late Successional Reserves (LSR) and Managed Late Successional Areas (MLSA) showed that non-winter recreation routes currently ranked as a low level of human influence on direct habitat loss (table 24). However, non-winter recreation routes had a high level of human influence on habitat effectiveness within 31% of the LSR/MLSAs, a moderate level in 56%, and a low level in 13% (table 25). Habitat effectiveness could be improved through human access management and opportunities could be identified during roads analysis (USFS 2000c) and project level analyses. Groomed and designated winter recreation routes have a low level of human influence on winter habitat effectiveness of late-successional habitats based on these analyses (table 26). Other winter routes that are not groomed or designated were not considered in this assessment.

Riparian habitats-The analysis of cumulative effects of non-winter recreation routes on riparian habitat effectiveness showed that 90% of the assessment units had a high level of human influence, 5% had a moderate level, and 5% had a low level (Table 27). This analysis showed that roads have the greatest cumulative effect on riparian habitat effectiveness. Opportunities to restore habitat effectiveness for riparian habitats could be identified during roads analysis (USFS 2000c).

The riparian habitat influence index estimates the cumulative effects that roads have on riparian habitats. This assessment showed five percent of the assessment areas had a high level of human influence, 21% had a moderate level, and 74% had a low level (table 28). Opportunities to restore riparian habitats through road management could be identified through roads analysis (USFS 2000c).

The winter route density index provides an estimate of the cumulative effects of winter recreation routes on riparian habitat effectiveness. This assessment showed that 11% of the assessment areas ranked as a high level of human influence, 28% as a moderate level, and 61% as a low level (table 29).

The assessments of riparian habitats showed that cumulative effects of linear recreation routes had the greatest impact from non-winter recreation routes, reducing habitat effectiveness. Habitat effectiveness of riparian habitats could be restored through route access management and restoration opportunities identified through roads analysis (USFS 2000c). Riparian habitats provide a habitat for a large number of wildlife species (Thomas et al. 1979) and therefore should receive high priority for restoration.

Waterfowl and colonial nesting bird habitats-The cumulative effects analysis for waterfowl and colonial nesting bird habitats showed that 72% of the assessment areas had a high level of human influence, 22% had a moderate level, and 6% had a low level (table 30). Based on this assessment, cumulative effects on these habitats are relatively high. These areas provide habitat for a large number of wildlife species and should be given high restoration priority. Opportunities to restore these habitats could be identified during roads analysis (USFS 2000c) and considered in project level evaluations.

Primary cavity excavator habitats-The cumulative effects analysis of roads on habitats for primary cavity excavators showed that 90% of the assessment units ranked as a low level of human influence and 10% ranked as a moderate level of human influence (table 31). Relative to other focal species habitats, cumulative effects do not appear to be a significant issue for primary cavity excavators within the assessment area.

Management Implications
This section provides information on the current condition of wildlife habitat for focal species relative to the cumulative effects of linear recreation routes. This information can be used to determine the significance of cumulative effects as an issue at the project scale. For example, if a project proposed within an assessment area ranked as currently having a high level of human influence, then cumulative effects would be an important issue to address. This issue could be addressed using the assessment models described in this document. This section also provides an evaluation of baseline conditions to which project level assessments can be tiered. Finally, this information can be used to identify priorities for restoration of important habitats. The most notable restoration needs based on this assessment are core areas for grizzly bears, late-successional habitats, riparian habitats, and wetlands.

Some tools that can be used to restore habitat effectiveness are described in general terms below and are based, in part, on Knight and Gutzwiller (1995), and Colorado State Parks (1998).

1. Spatial separation of humans and wildlife in key habitats. This approach could be used to address situations where displacement/avoidance interactions have been identified for a wildlife species of management interest.
2. Temporal separation of humans and wildlife at critical time periods. This tool could be applied where the interaction of displacement at a specific site has been identified for a wildlife species of management interest.
3. Human behaviors that reduce the effects of recreation on wildlife can be taught through information and education programs.
4. Design of facilities with wildlife habitat values in mind. If wildlife habitat issues are identified upfront in the early stages of projects, they can be addressed proactively through project design. Hopefully, the information provided in this assessment will help accomplish this.

In order to proactively address wildlife conservation and recreation opportunities, we need to begin addressing these issues through our landscape scale planning processes, such as forest level planning. In this manner important habitats for wildlife and recreational opportunities for humans can be identified. This process could be accomplished using the following approach:

1. Assess the existing level of influence that recreational activities have on wildlife habitats.
2. Set compatible wildlife habitat goals and recreation goals.
3. Gain further knowledge about wildlife and recreation interactions through an adaptive management approach.
4. Adapt habitat and recreation goals based on new information.

The following section provides a framework for how to approach adaptive management and monitoring. In this manner, we can address the mutual goals of conserving wildlife species while providing recreation opportunities. These goals have many commonalities, not the least of which is the desire of people to experience “wildlife” during their recreational outings.

Monitoring and Adaptive Management

Introduction
Monitoring has been identified as an integral part of an adaptive ecosystem management approach to natural resource conservation (Christensen 1997, Christensen et al. 1996, Everett et al. 1994, Gaines et al. 1999, Gutzwiller 1991, Gutzwiller 1993, Noss and Cooperrider 1994). Monitoring is defined as the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress towards meeting a management objective (Elzinga et al. 1998). Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs (Nyberg 1998). Adaptive management blends methods of scientific investigation with deliberate manipulations of managed systems. Adaptive management embodies a simple imperative: *policies are experiments and we must learn from them* (Lee 1993).

Adaptive management shares much of its theoretical basis with similar concepts from other fields. Examples include the continuous improvement process in business (Deming 1986, Walton 1986), adaptive control process theory in engineering, and operations research and management (McLain and Lee 1996). An adaptive management approach is particularly useful when dealing with complex management questions and high levels of uncertainty (Nyberg 1998, Walters 1986), both of which confront natural resource managers. One set of complex issues fraught with uncertainty is the management dilemma of balancing recreational opportunities with the conservation of ecological functions and processes. It would seem that using an adaptive management approach, coupled with credible monitoring, is critical to address these issues.

Scientists can play an important role in adaptive management (Walters 1986), but it is the local resource professionals who must become "adaptive managers" if the promise of the concept is to be realized through its application to natural resource management issues (Nyberg 1998). As part of their everyday jobs, resource managers must be able to design and implement studies that produce reliable information about complex natural resource issues.

An Adaptive Management and Monitoring Process

The process for designing and implementing an adaptive management project involves seven steps (based on Elzsinga et al. 1998): 1) background tasks, 2) develop objectives, 3) design and implement management, 4) design the monitoring methodology, 5) implement monitoring, 6) report and use results, and 7) adapt management approaches in light of monitoring results. These seven steps are described in detail below.

Step 1: Background tasks-This step involves the compilation and review of existing information, including relevant management direction. Important decisions to be made at this step include what the priorities are for monitoring (e.g. Focal species habitat or population), what resources are available for monitoring, appropriate temporal and spatial scales, and the intensity of the monitoring efforts.

Step 2: develop clear, well defined objectives-This is a very important step and one that is often overlooked. At this step general management goals and objectives are defined, and monitoring indicators are selected. The desired direction of change (e.g. A 10% increase in animal population numbers) is described and specific timeframes for achieving the desired direction are identified.

Step 3: Design and implement management-This is the step in which the project is implemented. An important concept to note is that monitoring should be considered as an integral part of the initial project design as opposed to an afterthought.

Step 4: Design the monitoring methodology-This critical step involves the identification of sampling objectives and methods, defining sampling units, estimation of the number of sampling units required, sampling frequency, and identification of the resources needed to carry out the monitoring. Randomization, stratification, and replication are important concepts to integrate into the monitoring methodology and have implications for the types of statistical methods that can be used in data analyses. Identification of the likely statistical methods that will be used in analysis is also important at this step. Seeking peer review of the monitoring methodology and statistical methods is very important and should be an integral part of this step. It is important that this step be completed along with project design so that project and monitoring objectives are integrated.

Step 5: Implement monitoring-This step includes the collection of field data, analysis of data after each measurement cycle, and evaluation of monitoring results. Periodic analysis after measurement cycles allows for adjustments to be made in the monitoring methodology.

Step 6: Report and use results-For monitoring and adaptive management to be successful the results, and their applications, must be displayed to managers, interested parties, and decision makers. In addition, it is important to leave tracks for successors as some monitoring may be long term. Seeking peer review of the analysis methods and results is very important and should be an integral part of this step.

Step 7: adapt management approaches in light of monitoring results-This step is self-explanatory and very important. If monitoring is irrelevant to how resources are managed then is it not useful. However, if monitoring is carried out in a manner that views management approaches as experimental, is designed into projects at their inception, and is done in a scientifically rigorous manner, then it can be used to guide management of natural resources.

A Hypothetical Adaptive Management Plan

Step 1. Background-There is a proposal to build a trail for motorized use in order to separate motorized from non-motorized trail recreation. The project occurs in a roadless area designated for motorized and non-motorized trail recreation and in a habitat reserve which emphasizes late-successional habitat for late-successional associated species. The land allocations have two goals: provide recreation trail opportunities and maintain security habitat for late-successional species. The specific security habitat goals were described in the reserve assessment (USFS 1997) which called for managing towards a goal of a "high" level of security habitat which is defined as >70% security habitat in the reserve. Application of the late-successional habitat cumulative effects models (as presented in this document) resulted in a concern by the Interdisciplinary Team (IDT) in meeting recreation needs and maintaining habitat effectiveness for wildlife. This prompted the IDT to propose an adaptive management approach for this project.

The focal species selected for monitoring include breeding birds associated with late-successional forests (brown creeper, pygmy nuthatch, white-breasted nuthatch, white-headed woodpecker) and the American marten.

Step 2. Objectives-The management goal is to maintain or improve security habitat for late-successional associated species while providing for trail recreation opportunities. The objective is to determine: 1) If motorized trail use decreases habitat effectiveness for the focal species, and 2) If non-motorized trail use decreases habitat effectiveness for the focal species. The indicators that will be monitored include: 1) Population indices for late-successional breeding bird species and American marten along the proposed motorized trail, along a non-motorized hiking trail, and in an area with no trails, and 2) The zone of influence which focal species may be affected by motorized trails and/or non-motorized trails, compared to control (trailess) areas.

Monitoring will be implemented for two field seasons following construction of the trail. Monitoring could lead to several possible management changes. First, monitoring may indicate that cumulative effects models need to be revised. Second, if monitoring results in modifications to the cumulative effects models then the cumulative effects of the current conditions (baseline conditions) will be reassessed based on the new information. Finally, monitoring results will be applied to the evaluation of any future project to assess habitat effectiveness for late-successional focal species in the habitat reserve.

Step 3. Project design and implementation-Due to the desire of the IDT to take an adaptive management approach, they will craft the decision notice to implement the project in three phases. Phase 1 would construct the trails beginning the first field season following a final decision. Phase 2 will be the monitoring of focal species during two field seasons immediately after completion of the trail construction. Phase 3 would include a final evaluation of the monitoring information and appropriate management adjustments to the cumulative effects model and re-evaluation of the trail network within the habitat reserve to assess attainment of security habitat goals. This example shows how management decisions can be crafted to incorporate adaptive management.

Step 4. Monitoring methodology-Monitoring of birds would take place during two breeding seasons immediately following completion of trail construction. Methods will be based on Hickman (1990) and Miller et al. (1998) and include bird point count stations (Ralph et al. 1993) located on and at various distances from motorized and non-motorized trails, and areas with no trails. A total of 72 point count stations will be located in similar habitats. A total of nine 150 m segments would be monitored, three each along the motorized, non-motorized, and no-trail areas. Table 32 summarizes the number of bird point count stations at various distances from the trails that would be monitored.

Monitoring of the American marten would rely on the track plate methodology from Zielinski and Kucera (1995) as modified by Foresman and Pearson (1998). Track plate monitoring would occur at various distances from the trails (table 32) and would include a total of 54 monitoring stations conducted during two summer field seasons following trail construction. A total of nine 150 m segments within similar habitats would be monitored; three each along the motorized, non-motorized, and no-trail areas.

Analysis of variance (ANOVA) will be used to compare the detection rates of the focal species at each distance from the trail and for each trail type. Alpha for significance testing will be set at 0.05.

Step 5. Implement and monitor-District recreation specialists and wildlife biologists will work cooperatively to implement and monitor the trail projects as described in the adaptive management plan and decision notice.

Step 6. Report and use-The district biologists and recreation specialists will summarize their monitoring results and present them to the district leadership team. The monitoring results and report will be peer reviewed and published to assure accuracy and objectivity, and to make them available for others to use.

Step 7. Management adjustments-Based on the monitoring results, the district leadership team will review the cumulative effects model and trail network within the habitat reserve to make adjustments to meet the goals for habitat effectiveness for late-successional wildlife species and to provide recreation opportunities.

Summary

Well thought out monitoring can be used to validate the assumptions of the cumulative effects models developed in this assessment, and to gain a better understanding of the interactions between wildlife and recreation. The use of adaptive management allows managers to acknowledge uncertainties and information gaps but still move forward with project design and implementation. To implement an adaptive approach researchers and managers will have to work closely together. But by learning as we go, through the use of monitoring for adaptive management, we will have a higher probability of accomplishing the mutual objectives of providing a high level of wildlife habitat effectiveness and offering recreation opportunities.

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Table 1. Comparison of classification schemes used to describe the effects of recreation on wildlife and the road and trail associated factors used in this assessment

Road and Trails Associated Factors[a]	Disturbance Type[b]	Recreation Activity[c]	Definition of Associated Factors
Hunting/Trapping	Disturbance Type 3	Harvest	Mortality from hunting or trapping as facilitated by road and trail access.
Poaching	Disturbance Type 3	Harvest	Increased illegal take of animals, as facilitated by trails and roads.
Collisions	Disturbance Type 3	Harvest	Death or injury resulting from a motorized vehicle running over or hitting an animal
Negative human interactions	Disturbance Type 3	Harvest	Increased mortality of animals (eg. Euthanasia or shooting) due to increased contact with humans, as facilitated by road and trail access.
Movement barrier or filter	Disturbance Type 2	Habitat Modification Disturbance	Interference with dispersal or other movements as posed by a road or trail itself or by human activities on or near a road/trail or road/trail network.
Displacement or avoidance	Disturbance Type 1	Disturbance	Spatial shifts in populations or individual animals away from a road/trail or road/trail network in relation to human activities on or near a road/trail or road/trail network.
Habitat loss and fragmentation	Disturbance Type 2	Habitat Modification	Loss and resulting fragmentation of habitat due to the establishment of roads/trails, road/trail networks, and associated human activities.
Negative edge effects	Disturbance Type 2	Habitat Modification	Changes to habitat microclimates associated with the edge induced by roads or trails

Snag or Downed log Reduction	Disturbance Type 2	Habitat Modification	Reduction in density of large snags and downed logs due to their removal near roads, as facilitated by road access.
Collection	Disturbance Type 3	Harvest	Collection of live animals for human use as pets (such as amphibians and reptiles), as facilitated by the physical characteristics of roads/trails or by road/trail access.
Route for Competitors/ Predators	Disturbance Type 2	Habitat Modification	A physical human induced change in the environment that provides access for competitors or predators that would not have existed otherwise.
Disturbance at a specific site	Disturbance Type 1	Disturbance	Displacement of individual animals from a specific location that is being used for reproduction and/or young rearing
Snow Compaction	Disturbance Type 3	Habitat Modification	Direct mortality associated with animals being crushed or suffocated as a result of snow compaction from snowmobile routes or groomed ski trails.

(a) Based in part on Wisdom et al. 1999.
(b) From Liddle 1997.
(c) From Knight and Cole 1995.

Table 2. Recreation trail- and road-associated factors with documented effects on habitat or populations of wildlife species, and the affected wildlife species groups

Road and Trail Associated Factors	Effects of the Factors	Eg: Wildlife Group Affected
Hunting/Trapping	Mortality from hunting or trapping as facilitated by road and trail access.	Wide-ranging carnivores Ungulates Waterfowl
Poaching	Increased illegal take of animals, as facilitated by trails and roads.	Wide-ranging carnivores Ungulates Waterfowl
Collisions	Death or injury resulting from a motorized vehicle running over or hitting an animal	Wide-ranging carnivores Late-successional Riparian associated Ungulates
Negative human interactions	Increased mortality of animals (eg. Euthanasia or shooting) due to increased contact with humans, as facilitated by road and trail access.	Wide-ranging carnivores Ungulates Late-successional
Movement barrier or filter	Interference with dispersal or other movements as posed by a road or trail itself or by human activities on or near a road/trail or road/trail network.	Wide-ranging carnivores Late-successional Riparian associated Ungulates
Displacement or avoidance	Spatial shifts in populations or individual animals away from a road/trail or road/trail network in relation to human activities on or near a road/trail or road/trail network.	Wide-ranging carnivores Late-successional Riparian associated Ungulates
Habitat loss and fragmentation	Loss and resulting fragmentation of habitat due to the establishment of roads/trails, road/trail networks, and associated human activities.	Wide-ranging carnivores Late-successional Riparian associated Ungulates Primary Cavity Excavators
Negative edge effects	Changes to habitat microclimates associated with the edge induced by roads or trails	Late-successional
Snag or Downed log Reduction	Reduction in density of large snags and downed logs due to their removal near roads or campsites, as facilitated by road access.	Late-successional Riparian associated Primary Cavity Excavators
Collection	Collection of live animals for human use as pets (such as amphibians and reptiles), as facilitated by the physical characteristics of roads/trails or by road/trail access.	Late-successional Riparian associated
Route for Competitors or Predators	A physical human induced change in the environment that provides access for competitors or predators that would not have existed otherwise.	Wide-ranging carnivores Late-successional Riparian Associated Primary Cavity Excavators
Disturbance at a specific site	Displacement of individual animals from a specific location that is being	Wide-ranging carnivores Late-successional

	used for reproduction and/or young rearing	Riparian associated Ungulates
Snow Compaction	Direct mortality associated with animals being crushed or suffocated as a result of snow compaction from snowmobile routes or groomed ski trails.	Late-successional Riparian associated

Table 3. Focal wildlife species that were identified for each of the six wildlife groups used in this assessment

Wildlife Group	Focal Species
Wide-ranging Carnivores	Grizzly bear, Lynx, Gray wolf, Wolverine.
Ungulates	Mule deer, Elk, Bighorn Sheep.
Late-Successional Forest Associated Species	Northern spotted owl, Northern goshawk, Brown creeper, American marten, Fisher, Northern flying squirrel, Pygmy nuthatch, White-breasted nuthatch, White-headed woodpecker.
Riparian Associated Species	Cascades frog, tailed frog, Harlequin duck, Bald eagle, Water shrew.
Waterfowl and Colonial Nesters	Common loon, Great blue heron, Eared grebe, Wood duck.
Primary Cavity Excavators	White-headed woodpecker, Three-toed woodpecker, Pileated woodpecker.

Table 4. A summary of the road and recreation trail associated factors for wide-ranging carnivores

Focal Species	Road Associated Factors	Motorized Trail Associated Factors	Non-motorized Trail Associated Factors	Snowmobile Route Associated Factor	Ski Trail Associated Factors
Grizzly Bear[a]	-Poaching -Collisions -Negative Human Interactions -Displacement/ Avoidance	-Poaching -Negative Human Interactions -Displacement/ Avoidance	-Poaching -Negative Human Interactions -Displacement/ Avoidance	-Disturbance at a Specific Site	-Disturbance at a Specific Site
Lynx[b]	-Down Log Reduction -Trapping -Collisions -Disturbance at a Specfic Site	-Disturbance at a Specific Site -Trapping	-Disturbance at a Specific Site	-Route for Competitors -Trapping	-Route for Competitors
Gray Wolf[c]	-Trapping -Poaching -Collisions -Negative Human Interactions -Disturbance at a Specific Site -Displacement/ Avoidance	-Trapping -Disturbance at a Specific Site	-Trapping -Disturbance at a Specific Site	-Trapping	-Information not available
Wolverine[d]	-Down Log Reduction -Trapping -Disturbance at a Specific Site -Collisions	-Trapping -Disturbance at a Specfic Site	-Trapping -Disturbance at a Specific Site	-Trapping -Disturbance at a Specific Site	-Trapping -Disturbance at a Specific Site

(a) Sources: Archibald et al. 1987; Claar et al. 1999; Hood and Parker 2001; Kasworm and Manley 1990; Mace and Waller 1996, 1998; Mace et al. 1996, 1999; Mattson et al. 1987; McLellan and Shackleton 1988, 1989; Puchlerz and Servheen 1998; Weaver et al. 1987; Wisdom et al. 2000.
(b) Sources: Banci 1994, Buskirk 1999, Claar et al. 1999, Koehler and Aubry 1994, McKelvey et al. 2000, Ruediger et al. 2000.
(c) Sources: Boyd and Pletscher 1999; Claar et al. 1999; de Vos 1948; Harrison and Chopin 1998; Mech et al. 1988, 1991; Mladenoff 1997; Mladenoff and Sickley 1998; Mladenoff et al. 1995; Thiel 1985; Thurber et al. 1994.
(d) Sources: Banci 1994, Claar et al. 1999, Copeland 1996, Koehler and Aubrey1994.

Table 5. A summary of the effects of roads and trails on grizzly bears and gray wolves

Human Activity	Focal Species	Dist. Use< Expected *Meters*	Density Use< Expected *km/km^2*	References
Roads	Grizzly bear	500		Mattson et al. 1987
Roads	Grizzly bear	100		McLellan and Shackleton 1988
Roads	Grizzly bear	200 -spring 100 -summer 400 -autumn		Aune and Kasworm 1989
Roads	Grizzly bear	914		Kasworm and Manley 1990
Roads	Grizzly bear	500		Mace et al. 1996
Roads and Trails	Grizzly bear	500		Hood and Parker 2001
Trails	Grizzly bear	813 -spring 878 -summer 1129 -autumn		Mace and Waller 1996
Trails	Grizzly bear	122 -spring, fall		Kasworm and Manley 1990
Roads	Gray Wolf		0.7 km/km^2	Harrison and Chapin 1998
Roads	Gray Wolf		0.45 km/km^2	Mladenoff et al. 1995
Roads	Gray Wolf		0.6 km/km^2	Mech et al. 1988
Roads	Gray Wolf		0.7 km/km^2	Thiel 1985

Table 6. Definitions of roads and trails used in the core area analysis to determine the level of influence of road and recreation trails on grizzly bear habitat

Road or Trail Type	Definition	Effect to Core Area
Impassable Roads	Roads that are not reasonably or prudently passable by conventional four wheeled passenger vehicles, motorcycles, or all-terrain vehicles. These roads are intended to remain closed for the long term (>10 years)	Any road classified as impassable during a bear analysis season would be included as "core area" for that season.
Restricted Roads	Roads that are restricted with gates or berms but receive occasional administrative use. These roads are not intended to be managed as closed for the long term (>10 years).	Any road classified as restricted during a bear analysis season would not be included as "core area" for that season.
Open Roads	Roads open to motorized use during any portion of an active bear season, or information is not available to verify the effectiveness of a gate or berm.	Any road classified as open during a bear analysis season would not be included as "core area" for that season.
Open Motorized Trail	Trails that are passable by motorcycles or all terrain vehicles and are not legally restricted.	Any trail classified as open motorized during a bear analysis season would not be included as "core area" for that season.
Open Nonmotorized Trail	Trails that are not reasonably or prudently passable by motorcycles or all terrain vehicles, but are not legally restricted, or any trail that is legally restricted to allow only nonmotorized use.	Any trail classified as open nonmotorized during a bear analysis season would be included as "core area" for that season unless it is a **"high use"** trail.
High Use Trail	Any nonmotorized trail that receives an average of 20 or more parties/week during the grizzly bear season being assessed.	Any trail categorized as high us during a season would not be included as "core area" for that season.

Table 7. A summary of the road and recreation trail associated factors for ungulate focal species

Focal Species	Road Associated Factors	Motorized Trail Associated Factors	Non-motorized Trail Associated Factors	Snowmobile Route Associated Factors	Ski Trail Associated Factors
Mule Deer[a]	-Hunting -Poaching -Collisions -Displacement/ Avoidance -Disturbance at specific site	-Hunting -Poaching -Displacement/ Avoidance -Disturbance at specific site	-Hunting -Poaching -Displacement/ Avoidance -Disturbance at specific site	-Displacement/ Avoidance	-Displacement/ Avoidance -Disturbance at a specific site
Elk[b]	-Hunting -Poaching -Collisions -Displacement/ Avoidance -Disturbance at specific site	-Hunting -Poaching -Displacement/ Avoidance -Disturbance at specific site	-Hunting -Poaching -Displacement/ Avoidance -Disturbance at specific site	-Displacement/ Avoidance	-Displacement/ Avoidance -Disturbance at a specific Site
Bighorn Sheep[c]	-Hunting -Poaching -Collisions -Displacement/ Avoidance -Disturbance at specific site	-Hunting -Poaching -Displacement/ Avoidance -Disturbance at specific site	-Hunting -Poaching -Displacement/ Avoidance -Disturbance at specific site	-Displacement/ Avoidance	-Displacement/ Avoidance -Disturbance at a specific Site

(a) Sources: Canfield et al. 1999, Cassier et al. 1992, Freddy et al. 1986, Johnson et al. 2000, Ward et al. 1980.
(b) Sources: Canfield et al. 1999, Cassier et al. 1992, Cole et al. 1997, Ferguson and Keith 1982, Johnson et al. 2000, Lyon 1983, Phillips and Alldredge 2000, Roloff 1998, Roloff et al. 2001, Roland et al. 2000, Schultz and Bailey 1978, Ward 1976, Ward et al. 1980.
(c) Sources: Canfield et al. 1999, Hicks and Elder 1979, King and Workman 1986, MacArthur et al. 1982, Papouchis et al. 2001.

Table 8. A summary of the displacement distances and mean distance from roads reported for ungulate focal species

Human Activity	Focal Species	Dist. Displaced[a]	Mean Dist.[b]	References
		meters		
Hiking	Mule Deer	191		Freddy et al. 1986
Snowmobiling	Mule Deer	133		Freddy et al. 1986
Hiking	Mule Deer	200		Ward et al. 1980
Hiking	Elk	86		Schultz and Bailey 1978
Skiing	Elk	650		Cassier et al. 1992
Skiing	Elk	Moved away from high-use (>8 persons/day) trail		Ferguson and Keith 1982
Hiking	Bighorn Sheep	50		MacArthur et al. 1982
Hiking	Bighorn Sheep	Did not affect sheep movements		Hicks and Elder 1979
Hiking	Bighorn Sheep		200 at which sheep first responded.	Papouchis et al. 2001
Road Driving <u><</u>1 vehicle/day	Bighorn Sheep		354	Papouchis et al. 2001
Road Driving 5-13 vehicles/day	Bighorn Sheep		490	Papouchis et al. 2001
Road Driving	Elk	400		Ward 1976
Road Driving	Mule Deer	800		Perry and Overly 1977
Road Driving (closed to vehicles but open to ATVs)			268-280	Johnson et al. 2000
Road Driving (low traffic >0-<u><</u>1/12 hr)	Elk		869-890	Johnson et al. 2000
Road Driving (medium traffic >1-<u><</u>4/12 hr)	Elk		909-1032	Johnson et al. 2000
Road Driving (high traffic >4/12 hr)	Elk		1103-1560	Johnson et al. 2000

(a) Refers to the average distance at which animals reacted to human activities and were displaced from the area.
(b) Refers to the distance that radio-collared animals were located from roads.

Table 9. The zone of influence applied to each side of a trail or road based on road type and use level for the bighorn sheep summer and winter habitat influence indices

Trail/Road Type and Status	**Zone of Influence (Applied to each side of a trail, road or motorized trail)** *meters*
Non-motorized trail (ski or hiking)	200
Motorized trail	350
Road ≤1 vehicle/day	350
Road >1 vehicle/day	500

Table 10. The zone of influence applied to each side of a motorized trail or road based on road type and use level for the deer and elk summer habitat influence index

Road Type and Status	**Zone of Influence (Applied to each side of a road or motorized trail)**
	meters
Motorized Trails	300
Closed Road (No vehicular traffic but open to ATVs)	300
Low Traffic Open Road (>0 - ≤1 vehicle/12 hours)	900
Moderate Traffic Open Road (>1 - ≤4 vehicles/12 hours	1000
High Traffic Open Road (>4 vehicles/12 hours)	1300

Table 11. **A summary of the road and trail associated factors for late-successional habitat associated focal species**

Focal Species	Road Associated Factors	Motorized Trail Associated Factors	Non-motorized Trail Associated Factors	Snowmobile Route Associated Factors	Ski Trail Associated Factors
Northern Goshawk[a]	-Negative Edge Effects -Disturbance at a Specific Site	-Disturbance at a Specific Site	-Disturbance at a Specific Site		
Northern Spotted Owl[b]	-Negative Edge Effects -Disturbance at a Specific Site	-Disturbance at a Specific Site	-Disturbance at a Specific Site		
Brown Creeper[c]	-Snag Reduction -Negative Edge Effects -Displacement/ Avoidance -Habitat Loss/Fragmentation -Route for competitors/predators	-Route for competitors/ predators -Displacement / Avoidance	-Route for competitors/ predators -Displacement / Avoidance	-Route for competitors/ predators	-Route for competitors/ predators
American Marten[d]	-Snag Reduction -Down Log Reduction -Negative Edge Effects -Trapping -Collisions Habitat Loss/Fragmentation -Movement Barrier/Filter	-Trapping	-Trapping	-Trapping	-Trapping
Fisher[e]	-Snag Reduction -Down Log Reduction -Negative Edge Effects -Trapping -Collisions -Habitat Loss/Fragmentation -Movement Barrier/Filter -Displacement/ Avoidance	-Trapping	-Trapping	-Trapping -Displacement/ Avoidance	-Trapping
Northern Flying Squirrel[f]	-Snag Reduction -Down Log Reduction -Negative Edge Effects -Movement Barrier/Filter				
Pygmy nuthatch[g]	-Snag Reduction -Negative Edge Effects -Displacement/ Avoidance	-Displacement /Avoidance	-Displacement /Avoidance		
White-breated Nuthatch[h]	-Snag Reduction -Negative Edge Effects -Displacement/ Avoidance	Displacement/ Avoidance	Displacement/ Avoidance		

White-headed woodpecker[i]	-Snag Reduction -Negative Edge Effects				

(a) Sources: Grubb et al. 1998, Hamann et al. 1999, Jones 1979, Reynolds et al. 1992, Wisdom et al. 2000.
(b) Sources: Swarthout and Steidl 2001, USFS 1997.
(c) Sources: Foppen and Reijnen 1994, Hutto 1995, Hickman 1990, Keller and Anderson 1992, Miller et al. 1998.
(d) Sources: Claar et al. 1999; Powell 1979, 1982; Weaver 1993; Wisdom et al. 2000.
(e) Sources: Claar et al. 1999; Powell 1979, 1982; Weaver 1993; Wisdom et al. 2000.
(f) Sources: Carey 1991, 1995; Wisdom et al. 2000.
(g) Sources: Foppen and Reijnen 1994, Miller et al. 1998, Wisdom et al. 2000.
(h) Sources: Foppen and Reijnen 1994, Miller et al. 1998, Wisdom et al. 2000.
(i) Sources: Hammon et al.1999, Miller et al. 1998, Wisdom et al. 2000.

Table 12. A summary of the road and trail associated factors for riparian associated focal species

Focal Species	Road Associated Factors	Motorized Trail Associated Factors	Non-motorized Trail Associated Factors	Snowmobile Route Associated Factors	Ski Trail Associated Factors
Cascade Frog[a]	-Collisions -Habitat Loss/ Fragmentation -Movement barrier or filter.	-Collisions -Habitat Loss/ Fragmentation			
Tailed Frog[b]	-Collisions -Habitat Loss/ Fragmentation -Movement barrier or filter.	-Collisions -Habitat Loss/ Fragmentation			
Harlequin Duck[c]	-Downed log Reduction -Disturbance at a Specific Site -Displacement/ Avoidance -Habitat Loss/ Fragmentation -Negative human interactions.	-Disturbance at a Specific Site -Displacement/ Avoidance - Negative human interactions	-Disturbance at a Specific Site -Displacement/ Avoidance - Negative human interactions		
Bald Eagle[d]	-Poaching -Disturbance at a Specific Site - Displacement/ Avoidance	-Disturbance at a Specific Site	-Disturbance at a Specific Site -Displacement/ Avoidance	-Disturbance at a Specific Site	Disturbance at a Specific Site
Water Shrew[e]	-Collisions -Movement barrier/filter -Habitat loss/ fragmentation -Downed log reduction	-Collisions		-Snow compaction -Displacement/ Avoidance	-Snow compaction

(a) Sources: Ashley and Robinson 1996, DeMaynadier and Hunter 2000, Fahrig et al. 1995, Gibbs 1998, Rei and Seitz 1990, Welsh and Ollivier 1998, Wisdom et al. 2000, Yanes et al. 1995.
(b) Sources: Ashley and Robinson 1996, DeMaynadier and Hunter 2000, Fahrig et al. 1995, Gibbs 1998, Rei and Seitz 1990, Welsh and Ollivier 1998, Wisdom et al. 2000, Yanes et al. 1995.
(c) Sources: Ashley 1994, Clarkson 1992, Hamann et al. 1999, Wallen 1987, Wisdom et al. 2000.
(d) Sources: Hamann et al. 1999, Harmota and Oakleaf 1992, Skagan et al. 1991, Stalmaster and Newman 1978.
(e) Sources: Baldwin and Stoddard 1973, Cole and Landres 1995, Hickman 1999, Knight and Cole 1991, Randgaard 1998, Schmid 1972.

Table 13. A summary of the road and recreation trail associated factors for waterfowl focal species

Focal Species	Road Associated Factors	Motorized Trail Associated Factors	Non-motorized Trail Associated Factors	Snowmobile Route Associated Factors	Ski Trail Associated Factors
Common loon[a]	-Disturbance at a specific site. -Displacement/ Avoidance	-Disturbance at a specific site. -Displacement/ Avoidance	-Disturbance at a specific site. -Displacement/ Avoidance		
Great blue heron[a]	-Disturbance at a specific site. -Displacement/ Avoidance	-Disturbance at a specific site. -Displacement/ Avoidance	-Disturbance at a specific site. -Displacement/ Avoidance		
Eared grebe[a]	-Disturbance at a specific site. -Displacement/ Avoidance	-Disturbance at a specific site. -Displacement/ Avoidance	-Disturbance at a specific site. -Displacement/ Avoidance		
Wood duck[a]	-Snag reduction -Disturbance at a specific site. -Displacement/ Avoidance	-Disturbance at a specific site. -Displacement/ Avoidance -Snag reduction	-Disturbance at a specific site. -Displacement/ Avoidance -Snag reduction		

(a) Sources: Anderson 1988, Ashley 1994, Belanger and Bedard 1989, Boellstorff et al. 1988, Gotmark and Ahlund 1984, Hamann et al. 1999, Henson and Grant 1991, Kelly 1992, Klein 1993, Madsen 1985, Markham and Brechtel 1978, McEneaney 1994, Owens 1977, Pierce and Simons 1986, Rodgers and Smith 1995, Titus and VanDruff 1981, Tremblay and Ellison 1979, Vos et al. 1985, Wallen 1987, Werschkul et al. 1976.

Table 14. A summary of the road and trail associated factors for primary cavity excavator focal species

Focal Species	Road Associated Factors	Motorized Trail Associated Factors	Non-motorized Trail Associated Factors	Snowmobile Route Associated Factors	Ski Trail Associated Factors
White-headed Woodpecker[a]	-Snag Reduction -Negative Edge Effects	NA	NA	NA	NA
Three-toed Woodpecker[a]	-Snag Reduction -Negative Edge Effects	NA	NA	NA	NA
Pileated Woodpecker[a]	-Snag Reduction -Down Log Reduction -Negative Edge Effects	NA	NA	NA	NA

(a) Sources: Bull and Holthausen 1993, Hamann et al. 1999, Hitchcox 1996, Hutto 1995, Milne and Hejl 1989, Raphael and White 1976.

Table 15. A summary of the species groups, focal species, cumulative effects indices, and assessment areas used in the Cumulative Effects of Roads and Recreation Trails on Wildlife Habitats case study

Species Group	Focal Species	Index	Assessment Area
Wide-ranging Carnivores	Grizzly Bear	Grizzly Bear Assessment Model	Bear Management Unit
Wide-ranging Carnivores	Gray Wolf and Wolverine	Gray Wolf and Wolverine Assessment Model	Bear Management Unit
Wide-ranging Carnivores	Wolverine	Potential Denning Habitat Index	Potential Denning Habitat within Bear Management Units
Wide-ranging Carnivores	Lynx	Lynx Assessment Model	Lynx Analysis Unit
Ungulates	Deer and Elk	Winter Habitat Influence Index	Winter Range Unit
Ungulates	Bighorn Sheep	Summer/Winter Habitat Influence Index	Summer/Winter Range Unit
Ungulates	Deer and Elk	Summer Habitat Influence Index	5th Field Watersheds
Late-Successional	Northern spotted owl, goshawk, brown creeper, American Marten, fisher, flying squirrel, pygmy nuthatch, white-breasted nuthatch, white-headed woodpecker.	Non-winter Habitat Influence Index	Late-Successional Reserves
Late-Successional	Northern spotted owl, goshawk, brown creeper, American Marten, fisher, flying squirrel, pygmy nuthatch, white-breasted nuthatch, white-headed woodpecker.	Non-winter Security Habitat	Late-Successional Reserves
Late-Successional	Northern spotted owl, goshawk, brown creeper, American Marten, fisher, flying squirrel, pygmy nuthatch, white-breasted nuthatch, white-headed woodpecker.	Winter Security Habitat	Late-Successional Reserves
Riparian	Cascades frog, tailed frog, Harlequin duck, bald eagle, water shrew.	Non-winter Habitat Influence Index	Riparian Reserves within 5th Field Watersheds
Riparian	Cascades frog, tailed frog, Harlequin duck, bald eagle, water shrew.	Non-winter Road Density Index	Riparian Reserves within 5th Field Watersheds
Riparian	Cascades frog, tailed frog, Harlequin duck, bald eagle, water shrew.	Winter Recreation Route Density Index	Riparian Reserves within 5th Field Watersheds
Waterfowl and Colonial Nesters	Common loon, great blue heron, eared grebe, wood duck.	Habitat Influence Index	Habitats within 5th Field Watersheds

Primary Cavity Excavators	White-headed woodpecker	Habitat Influence Index	Forested Habitats within 5th Field Watersheds

Table 16. The cumulative effects of roads and trails on grizzly bear habitat within Bear Management Units (BMUs) located within the Cumulative Effects on Wildlife Habitats case study area

BMU	Early Core	Relative Rank*	Mid/Late Core	Relative Rank*
Upper Chelan	87	Low	82	Low
Lower Chelan	62	Moderate	53	High
Upper Entiat	40	High	47	High
Lower Entiat	19	High	18	High
Chiwawa	60	Moderate	55	Moderate
Upper Wenatchee	73	Low	61	Moderate
Lower Wenatchee	38	High	39	High
Icicle	82	Low	73	Low
Peshastin	35	High	36	High
Swauk	63	Moderate	20	High
Cle Elum	81	Low	33	High

*High Level of Human Influence = <55% core area/BMU.
Moderate Level of Human Influence = 55-70% core area/BMU.
Low Level of Human Influence = >70% core area/BMU.

Table 17. The cumulative effects of roads and motorized trails on gray wolf and wolverine habitat within Bear Management Units (BMUs) located within the Cumulative Effects on Wildlife Habitats case study area

BMU	% No Roads	% 0.1-1 mi./mi.^{2}	% >1 mi./mi.^{2}	Relative Rank*
Upper Chelan		0	0	Low
Lower Chelan	57.3	9.9	32.8	Moderate
Upper Entiat	50.2	8.6	41.2	Moderate
Lower Entiat	6.7	9.1	84.2	High
Chiwawa	58.2	5.2	36.6	Moderate
Upper Wenatchee	67.1	6.8	26.1	Low
Lower Wenatchee	31.1	9.5	59.4	High
Icicle	84.3	4.0	11.7	Low
Peshastin	28.6	10.0	61.3	High
Swauk	13.9	8.7	77.3	High
Cle Elum	46.5	7.9	45.6	Moderate

*High Level of Human Influence = <50% of a BMU with an open road/trail density of <1mi./mi.^{2}.
Moderate Level of Human Influence = 50-70% of a BMU with an open road/trail density of <1mi./mi.^{2}.
Low Level of Human Influence = >70% of a BMU with an open road/trail density of <1mi./mi.^{2}.

Table 18. The cumulative effects of groomed and designated winter recreation routes on potential wolverine denning habitat within Bear Management Units (BMUs) located within the Cumulative Effects on Wildlife Habitats case study area

BMU	AC. Den Habitat	% >1 mi./mi.^{2}	% >2 mi./mi.^{2}	Relative Rank*
Upper Chelan	1700	0	0	Low
Lower Chelan	2777	0	0	Low
Upper Entiat	4351	0	0	Low
Lower Entiat	400	0	0	Low
Chiwawa	820	0	0	Low
Upper Wenatchee	2506	0	0	Low
Lower Wenatchee	3706	0.1	0	Low
Icicle	7707	0	0	Low
Peshastin	353	0	0	Low
Swauk	1972	0	0	Low
Cle Elum	1960	0	0	Low

*High Level of Human Influence = >25% of the LAU with route densities >2 mi./mi.^{2}.
Moderate Level of Human Influence = >25% of the LAU with route densities >1 mi./mi.^{2}.
Low Level of Human Influence = <25% of the LAU with route densities >1mi./mi.^{2}

Table 19. The cumulative effects of groomed winter recreation routes on lynx habitat within Lynx Analysis Units (LAUs) located within the Cumulative Effects on Wildlife Habitats case study area

LAU	%<1mi./mi.^{2}	% 1-2 mi./mi.^{2}	%>2mi./mi.^{2}	Relative Ranking*
Cascade Crest	19.5	23.0	57.5	High
Cooper Mountain	100	0	0	Low
Ferry Basin	100	0	0	Low
Hungry Ridge	100	0	0	Low
Indian Head Basin	100	0	0	Low
Copper Peak	100	0	0	Low
Upper Entiat	100	0	0	Low
Pyramid	99.9	0.1	0	Low
Lake Basin	82.9	13.9	3.2	Low
Chiwawa	93.2	6.8	0	Low
Garland	92.7	7.2	0.1	Low
Cougar	86.6	8.7	4.7	Low
Chumstick Mountain	70.7	10.8	18.5	Moderate
White River	99.4	0.4	0.2	Low
Little Wenatchee	100	0	0	Low
Nason	85.1	8.3	6.6	Low
Icicle Ridge	99.9	0.1	0	Low
Upper Icicle	98.6	1.0	0.4	Low
Enchantment	99.8	0.2	0	Low
Table Mountain	72.2	14.0	13.8	Moderate
Teanaway	83.6	11.1	5.3	Low
Waptus	92.6	6.2	1.2	Low
Sasse Ridge	73.1	10.8	16.1	Moderate
Silver	77.1	14.0	8.9	Moderate
Keechelus Ridge	63.9	13.1	23.0	Moderate

*High Level of Human Influence = >25% of the LAU with route densities >2 mi./mi.^{2}.
Moderate Level of Human Influence = >25% of the LAU with route densities >1 mi./mi.^{2}.
Low Level of Human Influence = <25% of the LAU with route densities >1mi./mi.^{2}

Table 20. The cumulative effects of groomed and designated winter recreation routes on deer and elk winter ranges within watersheds located within the Cumulative Effects on Wildlife Habitats case study area

Watershed	Acres of Winter Range *acres*	Percent Outside Zone Of Influence *percentage*	Relative Ranking*
Chelan	8856	92.4	LOW
Entiat	14561	95.9	LOW
Columbia	6093	63.6	MOD
Wenatchee	23123	92.9	LOW
	5292	87.9	LOW
Columbia	13244	98.7	LOW
Mission	12888	87.7	LOW
Columbia	2863	97.8	LOW
Swauk-Naneum	5273	95.4	LOW

*Low=>70% outside a zone of influence, moderate=50-70% outside a zone of influence, high=<50% outside a zone of influence.

Table 21. The cumulative effects of non-winter recreation routes on deer and elk summer ranges within watersheds located within the Cumulative Effects on Wildlife Habitats case study area

Watershed	Percent Outside Zone of Influence	Relative Ranking*
Lake Chelan		
Chiwawa		
Entiat		
White-Little Wenatchee		
Columbia River		
Mad		
Columbia River		
Wenatchee		
Nason		
Icicle		
Columbia River		
Cle Elum		
Peshastin		
Mission		
Yakima		
Columbia River		
Peshastin		
Swauk-Naneum		

*Low=>70% outside a zone of influence, moderate=50-70% outside a zone of influence, high=<50% outside a zone of influence.

Table 22. The cumulative effects of non-winter recreation routes on bighorn sheep summer ranges within located within the Cumulative Effects on Wildlife Habitats case study area

Bighorn Sheep Summer Range	Percent Outside Zone of Influence	Relative Ranking*
Lake Chelan	55.4	MOD
Swakane	33.8	HIGH

*Low=>70% outside a zone of influence, moderate=50-70% outside a zone of influence, high=<50% outside a zone of influence.

Table 23. The cumulative effects of groomed and designated winter recreation routes on bighorn winter ranges located within the Cumulative Effects on Wildlife Habitats case study area

Bighorn Sheep Winter Range	*Acres*	Percent Outside Zone Of Influence	Relative Ranking*
Lake Chelan	38204	93.7	LOW
Swakane	8283	95.0	LOW

*Low=>70% outside a zone of influence, moderate=50-70% outside a zone of influence, high=<50% outside a zone of influence.

Table 24. Table showing the results of the habitat influence index for late-successional forest habitats within Late-Successional Reserves (LSR) and Managed Late Successional Areas (MLSA) located within the Cumulative Effects on Wildlife Habitats case study area

LSR/MLSA	% Inside Zone of Influence	Relative Ranking*
Slide Peak	10.1	Low
Icicle	17.7	Low
Boundary Butte	24.5	Low
Sawtooth	0	Low
Shady Pass	10.8	Low
Chiwawa	14.0	Low
Lake Wenatchee	14.2	Low
Deadhorse	15.3	Low
Teanaway	6.4	Low
Swauk	23.9	Low
Eagle	22.8	Low
Twin Lake	3.6	Low
Tumwater	16.3	Low
Camas	22.0	Low
Sand Creek	12.4	Low
Natapoc	24.7	Low

*Low=<30% of the habitat in a zone of influence, Moderate=30-50%, High=>50%

Table 25. Table showing the cumulative effects of non-winter recreation routes on late-successional forest habitat effectiveness for Late-Successional Reserves (LSR) and Managed Late Successional Areas (MLSA) located within the Cumulative Effects on Wildlife Habitats case study area

LSR/MLSA	% Outside Zone of Influence	Relative Ranking*
Slide Peak	41.7	High
Icicle	56.5	Moderate
Boundary Butte	46.1	High
Sawtooth	59.9	Moderate
Shady Pass	63.6	Moderate
Chiwawa	56.3	Moderate
Lake Wenatchee	63.9	Moderate
Deadhorse	58.9	Moderate
Teanaway	56.3	Moderate
Swauk	38.1	High
Eagle	42.7	High
Twin Lake	82.8	Low
Tumwater	58.6	Moderate
Camas	42.7	High
Sand Creek	54.4	Moderate
Natapoc	49.2	Low

*Low=<30% of the habitat in a zone of influence, Moderate=30-50%, High=>50%

Table 26. Table showing the cumulative effects of groomed and designated winter recreation routes on late-successional forest habitat effectiveness for Late-Successional Reserves (LSR) and Managed Late Successional Areas (MLSA) located within the Cumulative Effects on Wildlife Habitats case study area

LSR/MLSA	% Outside Buffer	Relative Ranking*
Slide Peak	66.7	Low
Icicle	100.0	Low
Boundary Butte	99.0	Low
Sawtooth	100.0	Low
Shady Pass	98.3	Low
Chiwawa	84.2	Low
Lake Wenatchee	94.8	Low
Deadhorse	93.2	Low
Teanaway	96.0	Low
Swauk	84.8	Low
Eagle	10.0	Low
Twin Lake	100.0	Low
Tumwater	86.2	Low
Camas	100.0	Low
Sand Creek	100.0	Low
Natapoc	93.9	Low

*Low=<30% of the habitat in a zone of influence, Moderate=30-50%, High=>50%

Table 27. The results of the non-winter recreation route density index on riparian habitats within the Cumulative Effects on Wildlife Habitats case study area

Watershed	% < 1mi/mi^2	% 1-2mi/ mi^2	% > 2 mi/mi^2	Relative Ranking*
Chelan	28.0	22.7	29.0	High
Chiwawa	24.6	26.2	49.2	High
Entiat	17.5	23.7	58.7	High
White-Little Wenatchee	39.8	19.5	40.7	High
Columbia River	0	75.0	25.0	Moderate
Mad	7.2	15.6	77.1	High
Columbia River	40.2	9.4	50.5	High
Wenatchee	18.6	21.5	60.0	High
Nason	17.4	21.0	61.7	High
	84.3	8.9	6.8	Low
Icicle	30.4	30.0	39.5	High
Columbia River	38.0	33.2	28.8	High
Cle Elum	25.0	20.9	54.2	High
Peshastin	11.1	18.1	70.9	High
Mission	33.9	19.5	46.5	High
Yakima	14.7	24.2	61.1	High
Columbia River	22.9	7.7	69.3	High
Peshastin	16.9	31.6	51.5	High
Swauk-Nanuem	6.8	5.2	88.0	High

*High Level of Human Influence = >25% of the watershed with **>** 2 mi/mi^2
Moderate Level of Human Influence = >25% of the watershed with >1 mi/mi^2
Low Level of Human Influence = <25% of the watershed with > 1 mi/mi^2

Table 28. Table showing the results of non-winter riparian habitat influence index for watersheds located within the Cumulative Effects on Wildlife Habitats case study area

Watershed	**Riparian Habitat** *acres*	**% of Riparian Habitats within Buffer** *percentage*	**Relative Ranking***
Chelan	49351	5.6	LOW
Chiwawa	20361	13.0	LOW
Entiat	29234	21.9	LOW
White-Little Wenatchee	28239	9.9	LOW
Columbia River	10	0	LOW
Mad	9397	22.7	LOW
Columbia River	1860	35.3	MOD
Wenatchee	28073	33.9	MOD
Nason	9716	20.9	LOW
	1053	0.9	LOW
Icicle	20986	6.7	LOW
Columbia River	3116	23.6	LOW
Cle Elum	27991	4.5	LOW
Peshastin	11754	31.8	MOD
Mission	6840	20.1	LOW
Yakima	17860	14.9	LOW
Columbia River	1117	33.4	MOD
Peshastin	12180	14.6	LOW
Swauk-Nameum	4956	99.8	HIGH

*Low Level of Human Influence = <30% of the habitat in the watershed within a zone of influence.
Moderate Level of Human Influence = 30-50% of the habitat in the watershed within a zone of influence.
High Level of Human Influence = >50% of the habitat in the watershed within a zone of influence.

Table 29. The results of the winter recreation route density index on riparian habitats within the Cumulative Effects on Wildlife Habitats case study area

Watershed	% < 1mi/mi^2	% 1-2mi/ mi^2	% > 2 mi/mi^2	Relative Ranking*
Chelan	92	6	1	Low
Chiwawa	69	20	11	Moderate
Entiat	87	12	1	Low
White-Little Wenatchee	92	4	4	Low
Mad	78	9	13	Low
Columbia River	87	13	0	Low
Wenatchee	75	17	8	Moderate
Nason	64	20	16	Moderate
	59	41	0	Moderate
Icicle	99	1	0	Low
Columbia River	96	4	0	Low
Cle Elum	73	13	14	Moderate
Peshastin	82	17	1	Low
Mission	98	2	0	Low
Yakima	55	20	25	High
Columbia River	83	8	9	Low
Peshastin	86	9	5	Low
Swauk-Naneum	52	23	25	High

*High Level of Human Influence = >25% of the watershed with **>** 2 mi/mi^2
Moderate Level of Human Influence = >25% of the watershed with >1 mi/mi^2
Low Level of Human Influence = <25% of the watershed with > 1 mi/mi^2

Table 30. Table showing the results of the cumulative effects analysis for waterfowl and colonial nesting bird habitats for watersheds located within the Cumulative Effects on Wildlife Habitats case study area

Watershed	% of Habitat within a Zone of Influence	Relative Ranking*
Chelan	65	Moderate
Chiwawa	45	High
Entiat	37	High
White/Little Wenatchee	55	Moderate
Mad River	26	High
Columbia	49	High
Wenatchee River	32	High
Nason Creek	34	High
	96	Low
Icicle	44	High
Columbia	58	Moderate
Cle Elum	44	High
Peshastin	22	High
Mission Creek	54	Moderate
Yakima	42	High
Columbia	32	High
Peshastin	33	High
Swauk/Naneum	19	High

*High Level of Human Influence = <50% of the habitat in the watershed outside a zone of influence.
Moderate Level of Human Influence = 50-70% of the habitat in the watershed outside a zone of influence.
Low Level of Human Influence = >70% of the habitat in the watershed outside a zone of influence.

Table 31. Table showing the results of the cumulative effects analysis for primary cavity excavator habitats for watersheds located within the Cumulative Effects on Wildlife Habitats case study area

Watershed	% of Habitat within a Zone of Influence	Relative Ranking*
Chelan	6.7	Low
Chiwawa	13.6	Low
Entiat	21.0	Low
White/Little Wenatchee	7.8	Low
Columbia	6.5	Low
Mad River	29.2	Low
Columbia	45.1	Moderate
Wenatchee River	26.7	Low
Nason Creek	17.4	Low
	22.6	Low
Icicle	4.1	Low
Columbia	24.1	Low
Cle Elum	13.3	Low
Peshastin	28.9	Low
Mission Creek	15.3	Low
Yakima	23.9	Low
Columbia	27.0	Low
Peshastin	9.2	Low
Swauk/Naneum	47.5	Moderate

*Low Level of Human Influence = <30% of the habitat in the watershed within a zone of influence.
Moderate Level of Human Influence = 30-50% of the habitat in the watershed within a zone of influence.
High Level of Human Influence = >50% of the habitat in the watershed within a zone of influence.

Table 32. A summary of the monitoring efforts for the hypothetical adaptive management trail project to address the effects of motorized and non-motorized recreation trails on late-successional focal species

	No Trail *meters*				Non-motorized Trail *meters*				Motorized Trail *meters*			
Dist. from Trail/Center	0	100	200	300	0	100	200	300	0	100	200	300
No. Bird Point Count Stations	6	6	6	6	6	6	6	6	6	6	6	6
Marten Track Plate Stations		6	6	6		6	6	6		6	6	6

Figure 1. Hypothetical example showing the assumed relationship between increasing recreational use within wildlife habitats and the probability of focal species persistence and maintenance of ecosystem processes and functions.

Figure 2. Interactions between the 27 focal wildlife species and roads documented from the literature review. The proportion of focal species for which an interaction was documented from the literature is shown on the y-axis.

Figure 3. Interactions between the 27 focal wildlife species and motorized trails documented from the literature review. The proportion of focal species for which an interaction was documented from the literature is shown on the y-axis.

Figure 4. Interactions between the 27 focal wildlife species and non-motorized trails documented from the literature review. The proportion of focal species for which an interaction was documented from the literature is shown on the y-axis.

Figure 5. Interactions between the 27 focal wildlife species and snowmobile routes documented from the literature review. The proportion of focal species for which an interaction was documented from the literature is shown on the y-axis.

Figure 6. Interactions between the 27 focal wildlife species and ski trails documented from the literature review. The proportion of focal species for which an interaction was documented from the literature is shown on the y-axis.

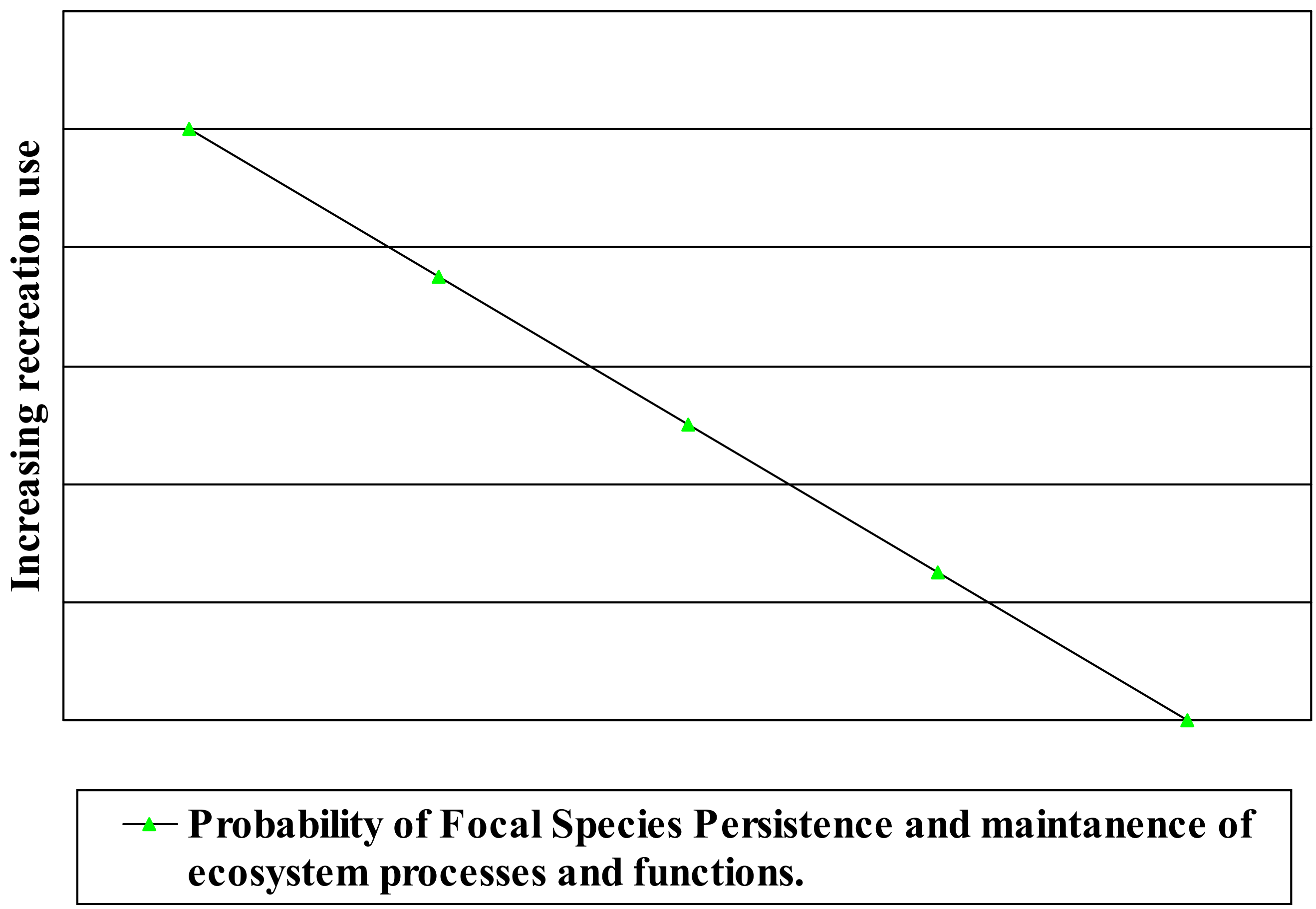

Figure 1. Hypothetical example showing the assumed relationship between increasing recreational use within wildlife habitats and the probability of focal species persistence and maintenance of ecosystem processes and functions.

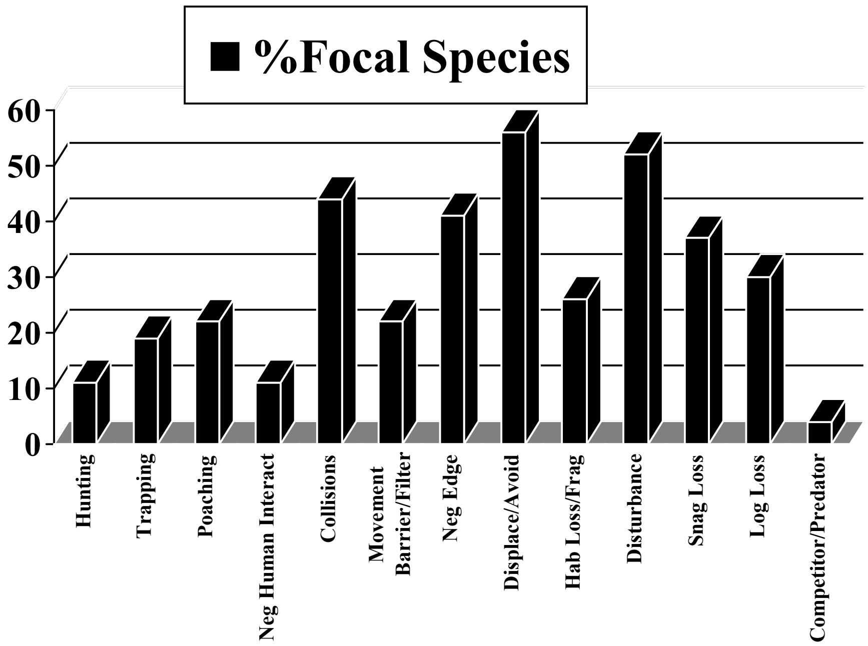

Figure 2. Interactions between the 27 focal wildlife species and roads documented from the literature review. The proportion of focal species for which an interaction was documented from the literature is shown on the y-axis.

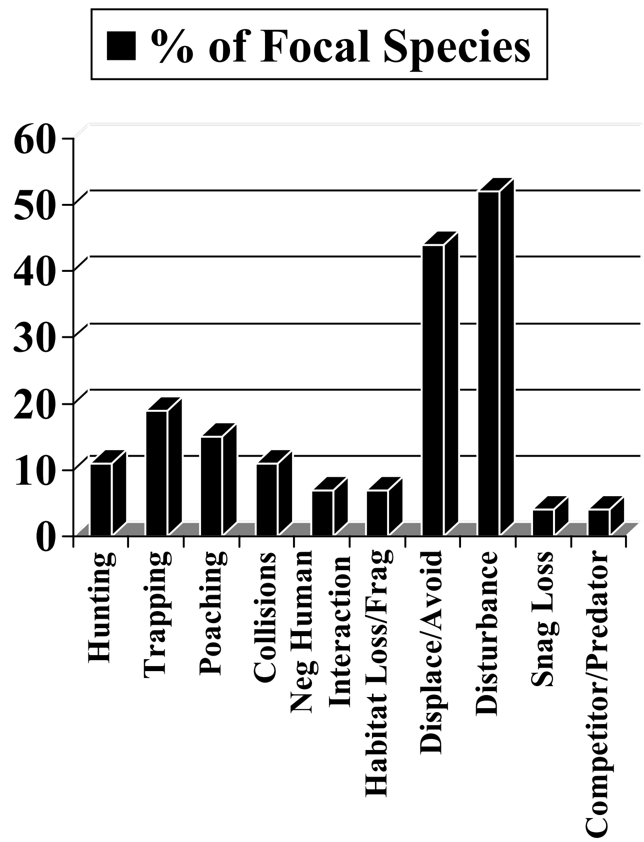

Figure 3. Interactions between the 27 focal wildlife species and motorized trails documented from the literature review. The proportion of focal species for which an interaction was documented from the literature is shown on the y-axis.

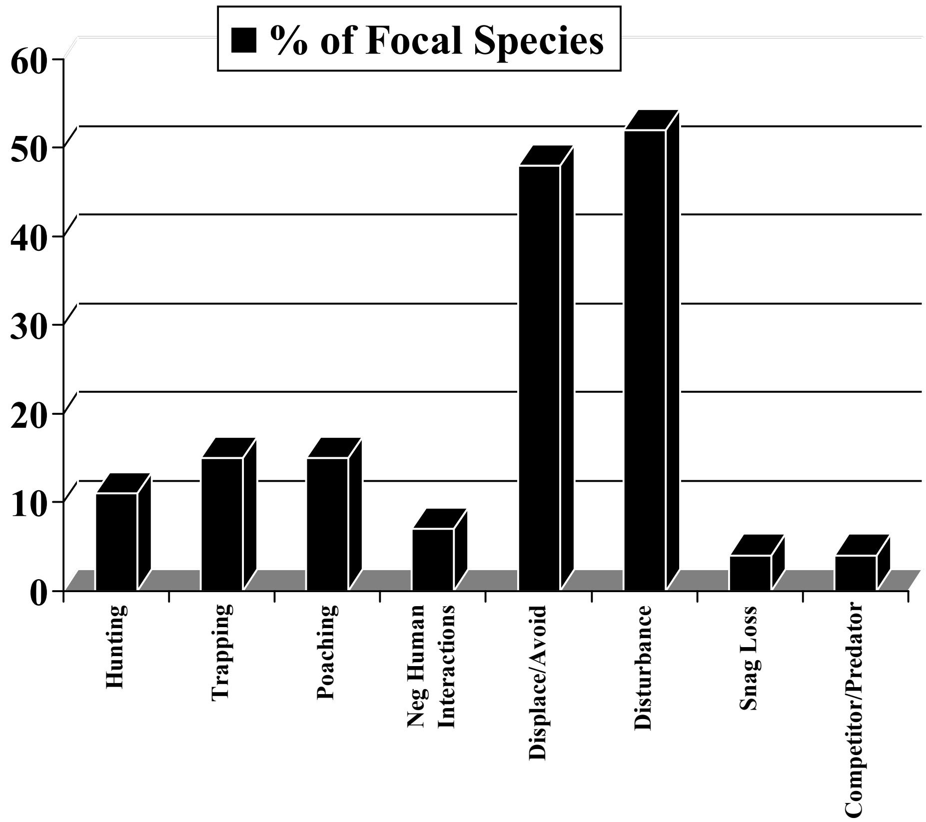

Figure 4. Interactions between the 27 focal wildlife species and non-motorized trails documented from the literature review. The proportion of focal species for which an interaction was documented from the literature is shown on the y-axis.

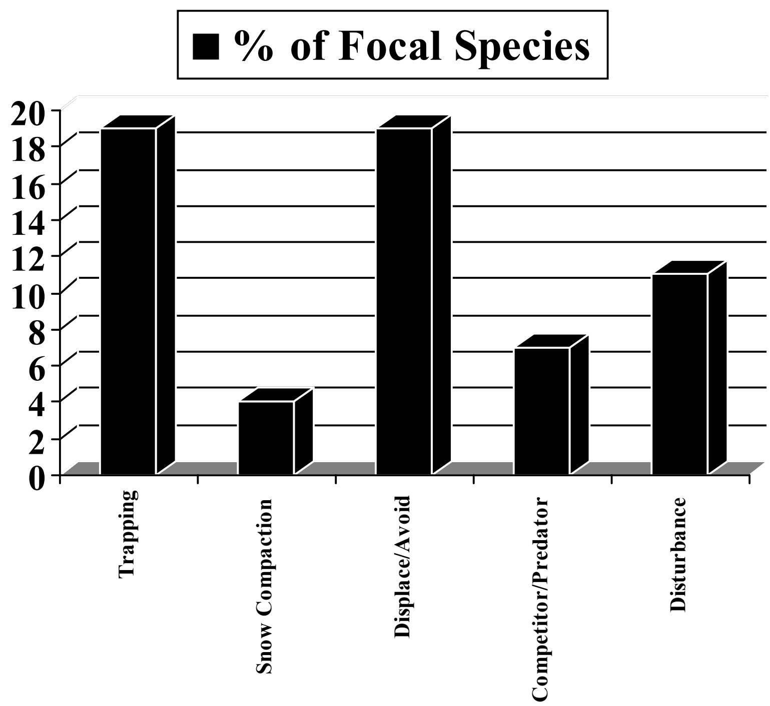

Figure 5. Interactions between the 27 focal wildlife species and snowmobile routes documented from the literature review. The proportion of focal species for which an interaction was documented from the literature is shown on the y-axis.

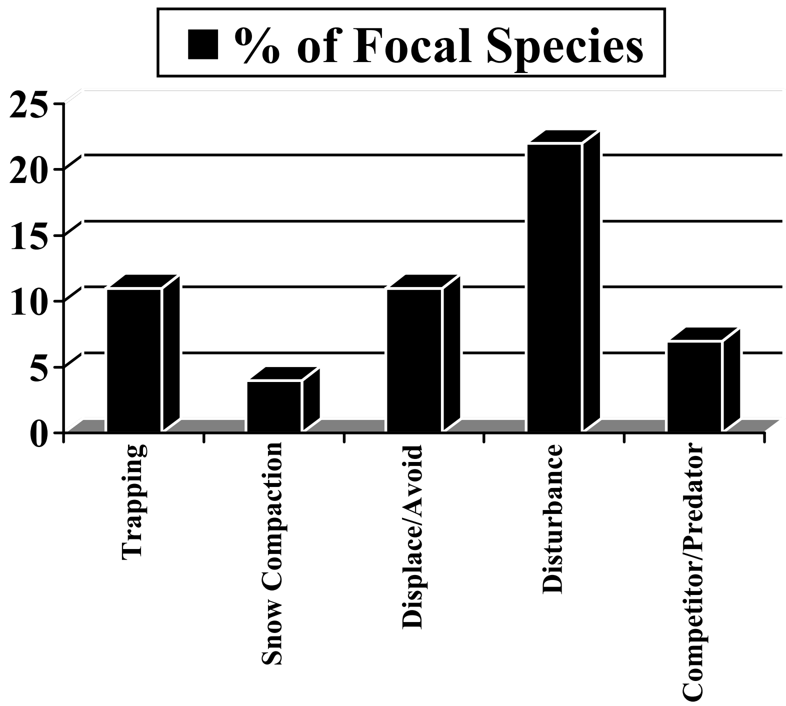

Figure 6. Interactions between the 27 focal wildlife species and ski trails documented from the literature review. The proportion of focal species for which an interaction was documented from the literature is shown on the y-axis.